

SYNTHESIS IN URBAN DESIGN

Notes on Systematic Techniques for Generating  
Alternative Designs for Urban Areas

by

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Education is Man's going forward from cocksure  
ignorance to thoughtful uncertainty --

K.G. Johnson

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## ABSTRACT

### Synthesis in Urban Design

#### Notes on Systematic Techniques for Generating Alternative Designs for Urban Areas

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This thesis is concerned with ways of designing in situations which are complex and constantly changing.

Two ideal models of the design process are presented as representing the two poles of desirable approaches to a design situation. The first model represents a cyclic method for the development of a single solution. The second ideal model outlines a cyclic method for the development of several alternative solutions in parallel. The second model is more exhaustive in that it initially expands the search for possible solutions before converging on a set of alternative solutions to be developed in detail. This model also requires larger available resources of time, money, skills and information.

The seven design processes identified are approaches which a designer uses or could use in complex urban design. The first three design processes are related to the first ideal model in that a single solution is developed at a time. They are also compared to the ideal model as to how well they meet the established criteria. The solution is developed in a single whole attempt, by fragmenting, or by either of these used in a recurrent manner. The last four design processes are concerned with the development of several alternative solutions in parallel, thus relating to the second ideal model. This could be done through the use of competitions, or the selection of multiple initial alternatives, both of which set out possible alternative solutions initially which are developed for choice. Another process uses the single probe for identifying a set of alternatives for development. Multiple probes expand the range of initial alternatives even further. Because all four of these processes can use the first three design processes within them, all design and idea techniques discussed for the first three processes can also be related to the other four.

Five groups of design techniques are related to the first two design processes. The sixth group of design techniques is useful in the third design process where recycling is expected, in that these techniques are concerned with testing the implications of solutions.

Three groups of idea techniques for stimulating creative ideas are presented which can be used within the seven design processes. A strong relationship seems to exist between Design Process I and the

free-association techniques for the development of a single solution. Check lists could be used in a supportive role. There also seems to be a strong relationship between Design Process II and the analytic and interaction techniques. These, together with check lists, fragment the problem into subproblems and then recombine the solutions to the subproblems into a single solution.

Also discussed are design environments such as the eclectic technique in which the designer freely combines design processes, and design and idea techniques for the development of a single solution or alternative solutions. New design environments are Discourse and Urban 5 which are trying to help the designer maintain this fluidity of approach and at the same time provide a framework for keeping track of design decisions; changing direction of search with greater ease; testing the consequences of design proposals; suggesting operations to perform; and allowing the designer to see the state of his progress. The designer and the computer thereby enter into a 'discourse' in the development of solutions to complex problems. These design environments show great promise for situations with many variables which are changing rapidly. They attempt to improve our ability for handling the complexity of dynamic situations by compensating for some of the designer's limitations of memory, energy, speed, patience and accuracy.

### ACKNOWLEDGEMENTS

The author is grateful to the Department of City and Regional Planning, especially to Kevin Lynch, thesis advisor, and to Professor John T. Howard for his patience, understanding and assistance over many years. Finally to my wife, Teddi, who has been a wonderful inspiration throughout this entire effort, a warm thank you.

## INTRODUCTION

This thesis outlines major design processes which a designer may use in attacking a complex problem. Related to each of these design processes will be specific design and idea techniques which can be used effectively within the different stages of these broad general design processes.

The purpose of presenting and relating these overall processes and the design and idea techniques is to expose their appropriate use so that the designer may more intelligently select his method of attack when confronted with a specific design problem.

## CHAPTER I

### MODELS OF THE DESIGN PROCESS

#### PART I THE COMPLEX CONTINUOUS DESIGN PROCESS

Complex urban design problems must deal with many variables and data which are uncertain, abstract and heavily dependent on long-range predictions. To compound the problem, the information, the problem constraints and the criteria will change or be altered radically during the design process. Within this design situation it is difficult for the designer to generate even one solution to a problem, let alone to conduct an exhaustive exploration of the problem and of the possible alternative solutions.

The formidable difficulties to be overcome in urban design are in assessing future needs which may not have existed before, and in exploring simultaneously a sufficient number of alternative solutions for that future in order to insure a successful solution. The second task is the concern of this paper.

Our inability to cope with the complex problems and to develop adequate alternative solutions, in part, is rooted in the design situation. The urban designer is presented not with a problem, but with a problem situation. It is within this complex situation that the designer must identify the problems which he hopes will prove to be relevant. He must also develop the design(s), test their performance, select one and develop a strategy for its implementation, as well as predict how it will influence and be influenced by the

original design situation which he is attempting to modify.

Beyond this complex task there are limitations which are common to many complex design situations. There is never enough time to collect and assimilate more than part of the relevant information or to perform more than an incomplete and oversimplified analysis. There is the difficulty of spotting errors before the design is well advanced. There is the high cost of altering or abandoning designs upon which much time has been spent.

It is this situation which drives us to repeatedly attempt to develop models of the design process with the hope that they may increase our understanding by more precisely describing the logical process involved. This obviously is in itself not enough, and we must strive to develop new tools or use existing ones which show promise for reducing the increasingly complex task to somewhat more manageable proportions.

There are many different approaches to the problem of structuring the planning and design process. Each approach has something to contribute to our understanding of the complex continuing design process, especially if we are concerned with improving the decision-making process in which human requirements are met by a design solution.

Models are used to present a description, at the most generalized level, of the logical implications of moving from a problem situation to an acceptable solution. Successful models are needed to produce a framework within which the designer's heuristic will be guided with a higher probability of success. Designers have always

operated under the influence of a model of their own, vaguely repeating certain reinforced procedures.

Design decisions are frequently made on inadequate data, and these same decisions commit us to future actions. These decisions must be reconsidered in the light of new knowledge, and frequently require that the designer return to an earlier stage in the process. Most of the models which I have reviewed are not totally adequate for describing a complex and dynamic design process in that they are not expressive of the recurrent nature of design. Such a recurrent design process would have the following important characteristics: it is not linear or chronological; it may be simultaneously active along several fronts; the sequence of attack may appear random or jumping back and forth; that it is cyclical; and that it may progress from the general to the specific, or run the other way around.

The following models attempt to describe this recurrent nature and the dynamics of a continuous design process. The purpose of these models is to communicate the complexity of the process, partially in terms of the following variables: number of clients; design time; scope of the problem; stability of the design situation; and resources of time, money, skills and information. The important role that the generation of alternative solutions plays within the entire design process will be identified.

Two models will be presented. One model will illustrate the cyclical, incremental development of a single solution. The other model will illustrate the cyclical development of multiple alternatives in series, simultaneously. Both are needed and useful in



complex urban design situations. If the urban designer is presented with a complex design situation where there are limited resources (time, money, manpower, information, etc.), he may not be able to develop several alternatives simultaneously. Instead, he must select the best strategy or design process for the incremental development of a single solution, or possibly a quick preliminary survey of workable things done in the past, or conduct incremental trials, etc. It may be possible in such a situation to consider multiple alternatives, but not in sufficient depth for adequate evaluation and comparison.

On the other hand, if such a complex design situation has with it ample resources, the designer should be able, if not obligated, to explore in depth multiple alternatives simultaneously which would allow for meaningful evaluation, comparison and selection.

## PART II      IDEAL MODEL I      The Development of a Single Solution

The first model is suggested an an ideal process for the development of one solution for a complex continuous design situation. It is derived from the basic ideas suggested in two other models of the complex continuous design process--one by Edmund Bacon;<sup>1</sup> the other by Kevin Lynch (see Appendix A).

### IDEAL MODEL I

1. Defect- The perceived defect or lack in the environment which is to be corrected is usually presented as a vague statement of need.
2. Confrontation- The very beginning of the design process is the confrontation with the design problem. It is in this first view of the problem that the role, context, constraints, powers, objectives, scope and type of solution are set. This stage of the design process should leave the widest latitude for the problem definition. Emphasis on detail should be avoided in that it may inhibit future flexibility in work. Also at this time one outlines the sources and costs of the information for later use. The variables and parameters should be specified in a qualitative way if possible.
3. Generate- Simultaneously:
  - a. A first-round solution should be developed for the problem as now defined. This solution will help direct the search for areas of conflict and also expose those areas which need more information in order that adequate decisions can be made. It directs the search for relevant data which

may be used to reset the criteria, objectives, etc. This first-round pass through a solution further clarifies and sharpens the understanding of the problem. If there is great difficulty in finding any solution and it is felt that the need cannot be fulfilled, then the problem definition might be changed so it is possible to generate a solution.

- b. Once the problem is recognized clearly and all parties concerned have agreed as to its nature, the first-round specifications or criteria become vital. These specifications must attempt to clarify the major constraints of the solution, the available resources, and the objectives of the project. Again, this should allow for flexibility in the future.
- c. Identify more specifically the new required data needed to continue the design program. Plan and conduct its collection so that it is consistent and is organized in such a way that new information can be introduced and processed easily.

- 4. Evaluate- The first-round solution should be evaluated by the client as to how well it satisfies the initially stated design objectives. It would be evaluated as to its physical and financial feasibility, involving possible costs and benefits and to whom they would accrue. The results of such an analysis may indicate that the design goals are impractical or that worthwhile objectives were not considered. This evaluation would require an up-to-date precise definition of

the problem and the reasons for decisions made. A meaningful discourse between the client and the designer could result which would in turn increase the depth of understanding, and therefore the quality of criticism of the client. The criticism and new understanding will be the basis for another solution to be generated.

5. Modify-

- a. It is necessary to return to an earlier stage, which may involve redefining the problem to take into consideration the new worthwhile objectives, resetting the criteria, gathering new relevant data and information, and then re-generating a solution to the newly defined problem.
- b. It may be useful to develop a partial predictive model of the solution. This would either be a mathematical or simulation model and would be used to explore the consequences of design decisions and to test the internal consistency.

Stages 3, 4, 5 are recycled until a solution is considered adequate by the client(s). Ideally, each recycling will make the definition more precise and consistent, and will bring the solution closer to the client's needs.

6. Implementation- When the solution is accepted the design process will continue if there are modifications and adjustments essential to the success of the project. It is important to reevaluate the project when it is in the process of implementation as some crucial and unforeseen changes may occur. In addition, there should

- be a follow-up evaluation of how the final solution environment satisfies the original objectives and goals. This should outline strengths and weaknesses and suggest implications for future work.
7. If a satisfactory solution is still not attained it may be necessary to abandon the entire project and strategy. If, however, a decision is made to continue, it may be essential to shift to a new problem or to concentrate on a different aspect of the previous problem.

### PART III      IDEAL MODEL II      The Development of Multiple Alternative Solutions

This model borrows greatly from two other models of the complex continuous design process--one by Roe, Soulis and Handa;<sup>2</sup> and the other by Kevin Lynch (see Appendix A). It is similar to ideal Model I except that multiple alternative solutions are generated instead of a single solution. The stages of this model will be explained only when they differ from those of the first model.

#### IDEAL MODEL II

1. Defect- (see Model I)
2. Confrontation- (see Model I)
3. Generate- (see Model I)

This stage is similar except that several first-round solutions are developed.

4. Evaluate- The first-round alternative solutions should be evaluated with the client, if possible, as to how well they satisfy the

initially stated design objectives. Some alternatives will be rejected and new possibilities may arise. From this evaluation new goals and objectives may be determined, and the problem should be more clearly understood.

5. It is necessary to explore in greater detail and modify the alternative solutions which seemed most promising. The data base has to be kept current for all these possible solutions. After the modifications new solutions are generated which reflect all the new information and revised objectives.

Stages 3, 4, and 5 are recycled until a number of alternative solutions are developed. With each pass the alternatives should be more clearly defined, until the client can be presented with a range of internally consistent and well-documented solutions.

6. Selection- After final evaluation and comparison, the client may select one of the solutions for implementation.
7. Implementation- (see Model I, Stage 6)
8. Rejection- (see Model I, Stage 7)

## CHAPTER II

### SEVEN DESIGN PROCESSES

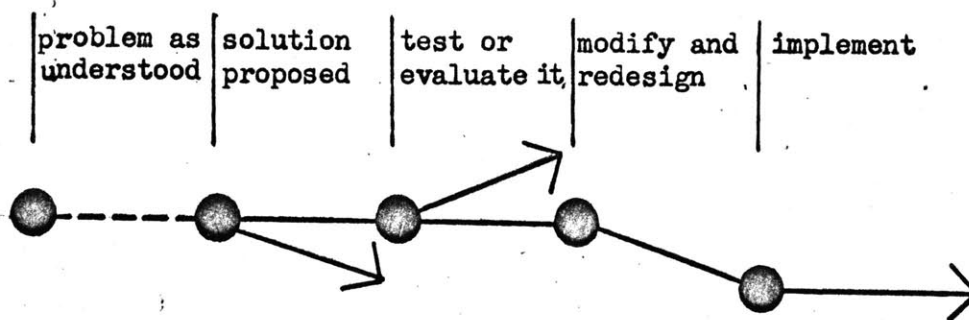
In the first chapter we outlined and described two broad ideal models for complex continuous urban design situations. This chapter will describe seven specific design processes which are related to both of these models: those relating to ideal Model I seek to develop a single solution; those relating to ideal Model II seek to simultaneously develop several alternatives. In addition these design processes are structured around whether a solution is considered as a whole or is fragmented into parts; or whether it is sequentially developed or developed by jumping around, trying to seize the essential.

#### PART I

##### Design Processes for the Generation of a Single Solution to a Problem

###### Design Process I (Single, Whole)

A single whole solution is developed incrementally and sequentially, then implemented.



This strategy or design process is most useful when the resources of a large-scale design situation are limited--when there is not enough money, time or there are too few human resources at one's disposal. In producing an adequate solution to a complex problem, this strategy often involves looking at previous solutions, resorts to trial and error, or attempts to seize the essential in order to produce workable solutions. In addition, many solutions are derived directly from the background of an individual with a great deal of experience.

An example of this design strategy is illustrated by L'Enfant's design of Washington D. C. In this situation he came to the site with a short time and limited resources with which to prepare a plan for the city. To save time he used a stereotype, the concept of the Baroque Axes, as the guiding principle for the design of the plan. This use of a stereotype allowed him to complete the surveying and planning within less than a year.

A more recent illustration of this approach would be the planning of military bases. In this case the rectangular or square grids provide the concept that produces an orderly plan quickly. Lynch outlines many other stereotypes or concepts at the project, city and regional scale which are the bases of almost all designs. (see Appendix B) Their use provides an expedient way to design.

This strategy is effective and still useful because we can evaluate previous solutions, and by modifying slightly the problems or defects, a new solution can be developed with little risk of total



A major drawback of developing only one solution is that the designer may have overlooked a better solution(s). These might have surfaced had there been more exploration, further clarification of objectives and criteria, more redesign and greater client participation. All this is almost impossible in a one-shot affair, especially in complex problems where many hidden or unobvious objectives do not surface in a single pass. By not recycling, the designer eliminates the use of new information which occurs while the design progresses. Another drawback comes from limited client participation and feedback. If the client only participates in the initial definition and outlining of the objectives and not again until the final analysis and evaluation, the designer and the client may have defined a problem which has changed radically by the time a solution has been developed.

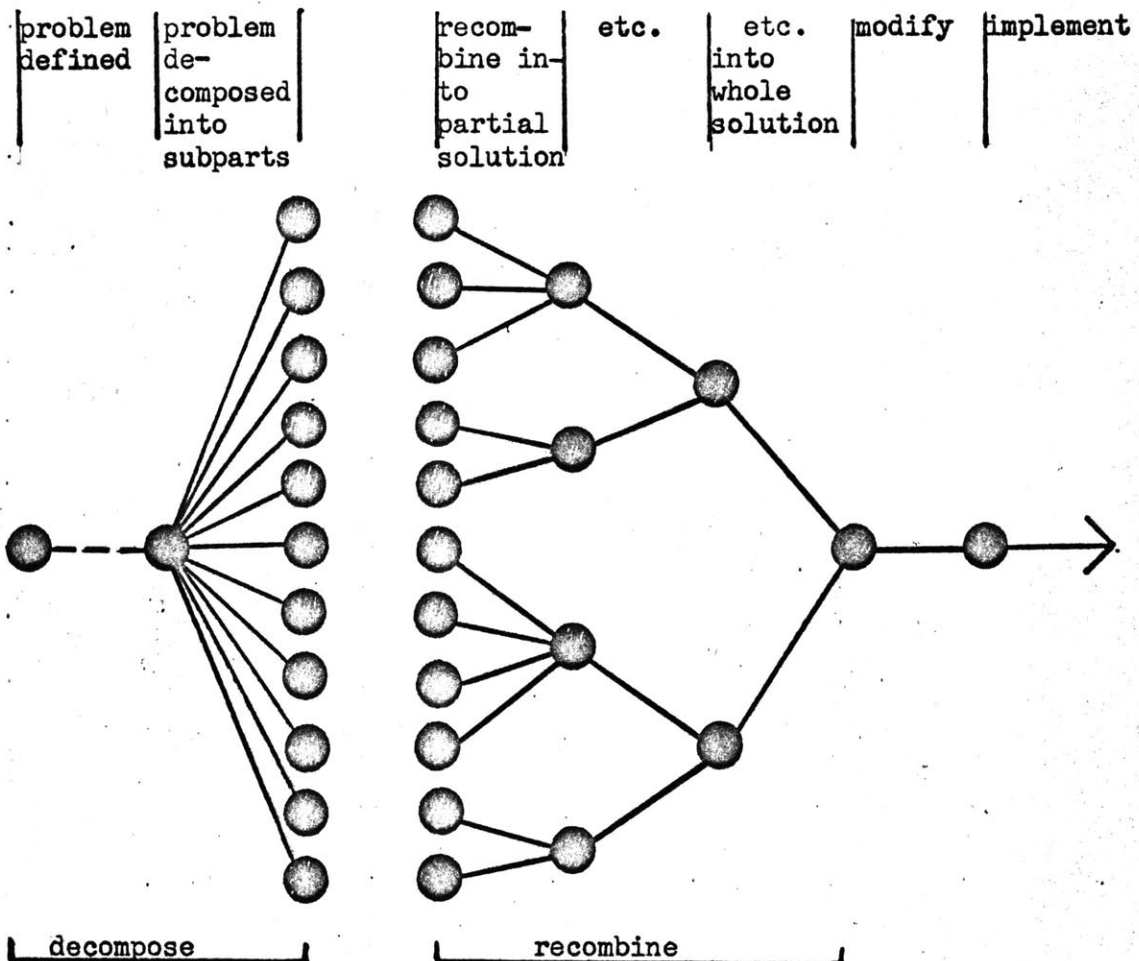
#### Design Process 2 (Single, Fragmented)

A single solution is developed by fragmenting the problem into its parts or subproblems. This design process generally involves the following stages: <sup>1</sup>

1. The aims, objectives and criteria for the design effort are determined.
2. The context and factors effecting the design situation are identified, including all relevant information.
3. The problem is fragmented into components:
  - a. by physical systems or areas
  - b. by activities, their requirements and settings
  - c. by criteria, general or detailed

4. Pairs or groups of interacting components are designated "subproblems".
5. These subproblems are ranked according to their importance if possible. This is done to indicate which set of subproblems should take precedence if a conflict arises.
6. Solutions are proposed for these subproblems.
7. These solutions to subproblems are recombined in a single whole solution (exact means is not described).

The advantage of this process is that the problem is broken into more manageable parts, and the interrelation of these parts is more easily seen.



This design process places a high premium on knowing exactly what the problem is in the beginning, something not always possible in complex situations which have many variables and in which a situation is constantly shifting. The sequential nature of this process would suggest that one may be led into solving the wrong problem, if the problem has been incorrectly defined in the beginning. This points out a weakness of this process--it does not recycle and there is no provision for accepting new, perhaps crucial information.

This process could be made more helpful to the urban designer if it were to be used within a cyclical process with the various cycles increasing in complexity as the problem objectives and criteria became more clearly understood. This could also help solve the problem of limited client participation. As the process stands, the client is only involved in the beginning of the process, and possibly in the solution of subproblems. If the process were made recurrent, the client would be involved more frequently throughout the design development. This modified process could be used for complex continuous design on less complex problems which are more technical in nature, which are relatively stable and which require limited client participation.

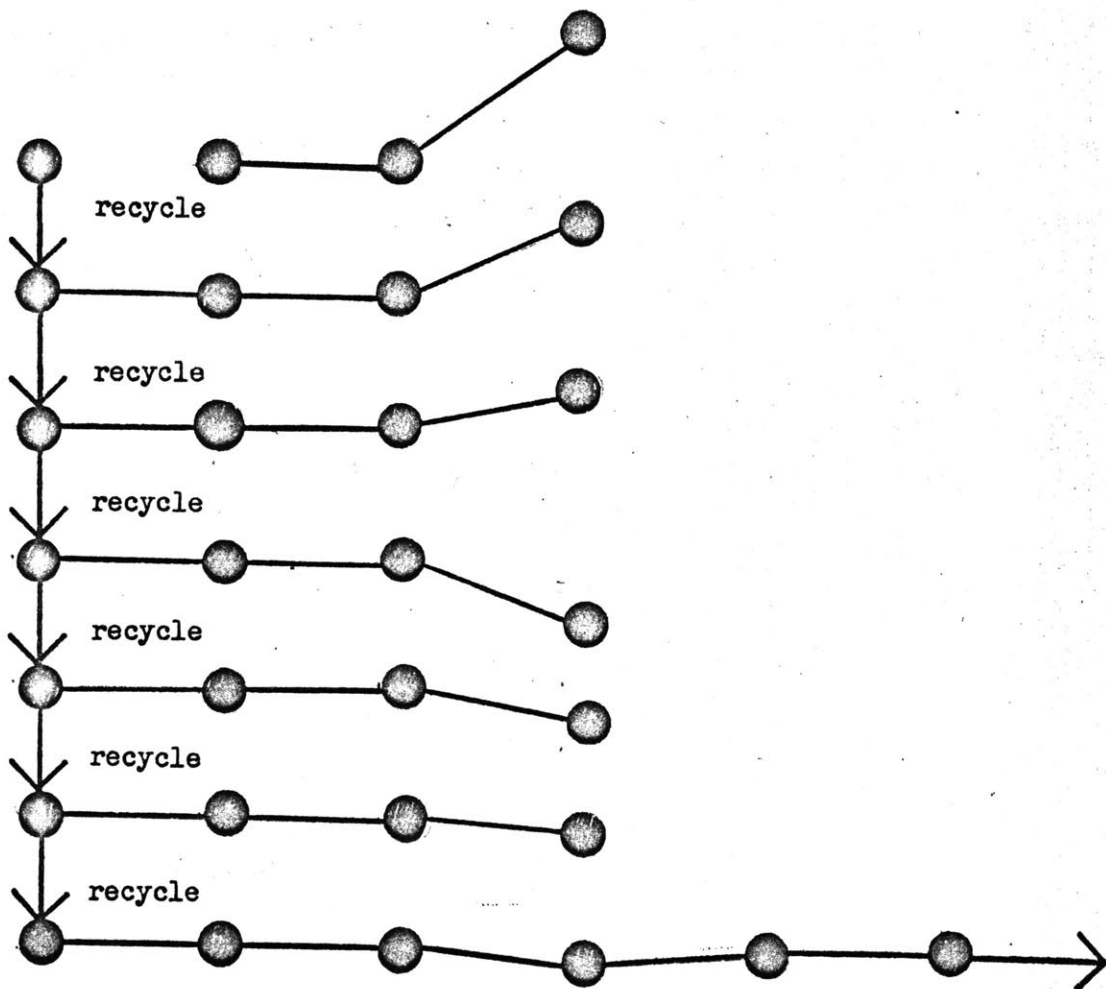
### Design Process 3      (Single, Recycled)

A single whole solution is developed, but is expected to be rejected by the client. Then the designer recycles and another solution is attempted which may also fail. This recycling process is continued until an acceptable solution is reached. The client and the

designer, through a process of trial and error, attain an acceptable solution.

This is the closest design process to the ideal Model I for the cyclic development of a single solution, but the ideal model is more exhaustive and explicit.

solution generated for pro- blem as understood	solution evaluated by client	solution rejected, problem redefined, recycle	solution selected	slight modification, implement
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Edmund Bacon<sup>2</sup> feels that a public designer should generate a design which will be evaluated and redefined by the client group. He modifies that solution or regenerates another solution, so that the task of the designer is to generate, modify or redesign in a recurrent process. In practice Bacon frequently uses a number of designers in this process. He commissions a designer to propose a design solution for a problem and then has him present his solution to the client group. Through the evaluation and criticism of the design, Bacon gets a better idea of the scope of acceptable solutions. He then invites another designer to propose another solution to the revised program. This process is repeated until a solution meets with acceptance.

This is a hard use of designers, but it is a way of generating different alternative solutions in sequence to complex problems. It gets around the problem of having one designer present a "pet" solution along with hurriedly assembled alternative solutions because of insufficient time to explore more than one design in great detail.

This strategy or design process is useful when the resources are ample to allow a longer and more extensive design to be developed--that is when there is enough time, money and human resources available. The client participation is limited to the initial stages and the final analysis of each cycle of the recurrent design process. Yet this periodic participation allows the designer and the client to redefine and reset the objectives, and redesign in a recurrent manner, facilitating over a long period of time the introduction of new information

and ideas.

This series of solutions in sequence allow the designer and client to make limited jumps to what appear to be better solutions. This is the result of the chopped nature--that of trial and error--of the design process. These jumps, however, may be limited because two factors: one is that since the initial design may lead to several alternatives, and only one is pursued, the process is only exploring part of the possible solutions; the other is that the restrictions may be built up once a designer proposes a solution. This tends to direct the group, and it would take great effort and imagination on the part of both the designer and the client to make major jumps away from the direction initially outlined.

Because only one solution is presented at a time, this process does not have a comparison among alternatives which may lead to other new solutions or combinations of proposals. This presentation of a single solution will not, however, confuse the client as much as if confronted with multiple alternatives to choose from and discuss. Yet this recycling process must be repeated many times before there is meaningful client participation. The client should know he is involved in a process of gradual evolution. If he does not receive the first solution for what it is--a probe to elicit client/designer interaction--he may lose confidence in the designer.

This third process allows the designer to use within it the two previous processes. This suggests that the development of the single solution could be done in whole or by fragmenting the problem. It may be developed sequentially or by jumping around trying to seize

a better solution. Any of these strategies could be employed in the development of a single solution as long as it is developed in a recurrent manner as suggested by the cyclic design process.

## PART II

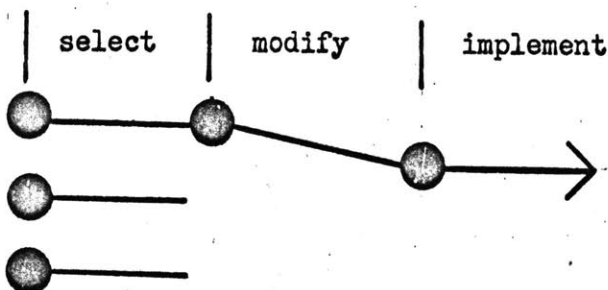
### Design Processes for the Simultaneous Generation of Multiple Alternative Solutions to a Problem

#### Design Process 4 (Competitions)

Multiple whole solutions are generated initially by groups or individuals. A scheme is selected, modified and implemented.

The use of competitions or a dispersed team approach, where each designer in the team is expected to generate one solution, is a method of generating alternatives which are analyzed and evaluated. This design process may incorporate the Design Processes 1, 2, and 3 for the development of a single solution. Because of the lack of time in most competitions, probably one of the first two processes would be used, where there is no recycling. This means that most of the entries or submissions in this process will be one-shot attempts and will therefore inherit all the drawbacks of those processes.

The following diagram illustrates the use of competitions or the dispersed team approach.



An alternative approach may be a competition which was devised in such a way that performance specifications were written for the environment (see Appendix C). These would then become the basis of evaluation for the competition. We have utilized this process in the design of building systems,<sup>3</sup> and it is possible that such a process could also be useful in the design of transportation systems, open-space networks, and parts and wholes of cities.

The first stage of such an approach would be a competition for the preparation of environmental performance characteristics. The competing teams would be composed of sociologists, psychologists, economists, political scientists and designers who would analyze the situation and identify the problem. The aim of this first competition would be in establishing the social, economic and political goals for the environment--those for which performance characteristics can be developed. After these are formulated there would be a second competition for the design of the physical environment which responded to these performance characteristics. This aspect of the approach would be an extension of the following view:

...The sociologists are not determining the design or construction of homes, neighborhoods, or cities from their research. They are, rather, offering suggestions for optimal spatial arrangements with consideration for stated criteria of mental health, family and community organization, and the like. The physical designer, on his part, must now come forward with the most efficient physical means to produce the requisite spatial units. He is no longer required to play amateur sociologist, psychologist, or the like; but he is taxed with the challenge of creating a given spatial structure by means that he or his city can afford and which are politically acceptable. In making his role explicit, the division of labor I suggest puts a greater--not lesser--burden of innovation on the designer than he has now.<sup>4</sup>



In a process using competitions the relevance of all the submissions depends to a great extent on the quality of the program, as well as the quality of the participating designers. Yet, even if the program were adequate, the situation may have changed so radically during the whole process that the solution selected may be obsolete, even though it may satisfy the program. An illustration of this would be the competition held for the Boston City Hall. By the time the competition was held and the complex built, the design was inadequate in terms of space requirements in that many of the departments which were to move in had grown over that period of five to six years. This would suggest that the competition system may not be adequate as a system for city or urban design when the situation is changing rapidly. (The adaptability of the environments we design has been discussed in more detail elsewhere.)<sup>5</sup>

Even if we accept competitions as necessary, we are faced with the task of selecting the proposal to be implemented. We presently have no good methods or techniques for evaluating the fit between the program and the solution which is often described in drawings, models, etc. This may mean that we should try presenting solutions in a form which would allow comparison, beyond the superficial qualities of rendering. An illustration of not being able to make meaningful comparisons was experienced in the jury for the selection of a proposal for the Golden Gateway Urban Renewal Project in San Francisco. When the selection process reached a few workable solutions, they had no way of going further. These solutions were then presented in a consistent way, allowing the jury to compare

the solutions very closely, and to tabulate the pros and cons of each proposal. There have been attempts at trying to systematize the process of evaluation at the urban scale which show promise of partial success.<sup>6</sup>

Another unfortunate characteristic of this process is that it stops short at the very time when other better alternatives may have resulted. Each of the alternatives are discussed in terms of evaluation and modification, but this may be lost when one solution is selected.

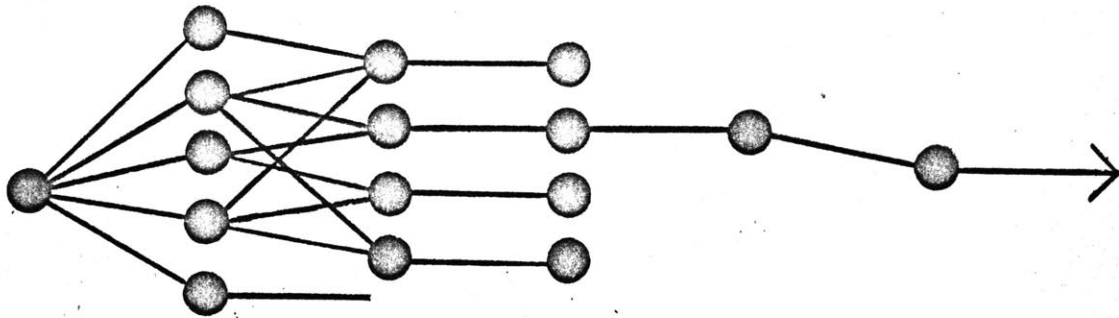
#### Design Process 5 (Multiple Alternatives Suggested Initially)

Multiple whole alternatives are selected initially. These are then analyzed, recombined and a few are selected for final development and eventual selection. This is a process of initially expanding the solution realm, developing several alternatives and then converging on a solution.

Three or four alternative proposals are selected by any means and then evaluated in the light of several objectives. Some will be ruled out because they are not within an acceptable range of standards. The rest are compared and evaluated as to how well they meet the stated objectives. These alternatives are open for debate and serve to direct public discussion which will possibly sharpen, weigh and resolve conflicting goals. In essence this process directs the efforts of criticism and debate so as to define objectives and resolve conflicts.

The following diagram illustrates this design process. It is related to ideal Model II, but the ideal model is more exhaustive and explicit.

diverge	modify, evaluate, recombine, eliminate	develop a select set	choice is made	slightly modify	implement
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In the initial stages this process does attempt to expand the range of solutions by establishing a set of alternatives instead of a single solution. These are done rather quickly, however, and some important possibilities may be missed. The process of development seems to be one of converging to a solution. While there is evaluation and modification, this process does not suggest further exploring and expansion of the solution realm. This process is efficient, and the solution may be internally consistent; however, it may not be the best solution.

The resources needed are more extensive in this process in that an individual or group is studying several alternatives over a period of time as well as presenting them for final evaluation. These alternatives must be well thought out and represent a range of possibilities in order to justify the additional resources. Perhaps the initial alternatives proposed could be more carefully selected than this process implies, so that the range of possibilities might be better considered. As it is now, the initial alternative

solutions are selected using one of the first two design processes for single solutions, thus inheriting all the limitations related to their use.

Because the alternatives are open to public debate and reaction, the last-minute modifications may be incorporated into the design selected. As a result of this combining or modification, this process is a little more adequate for complex problems than the process of competitions. This process also allows for co-ordination so that the presentation of alternatives is in a form which makes comparisons and evaluation possible.

This process would be made more meaningful if the alternatives which were discussed and evaluated were recycled again so that the better ones might be brought closer to meeting the objectives.

#### Design Process 6 (Single Probe)

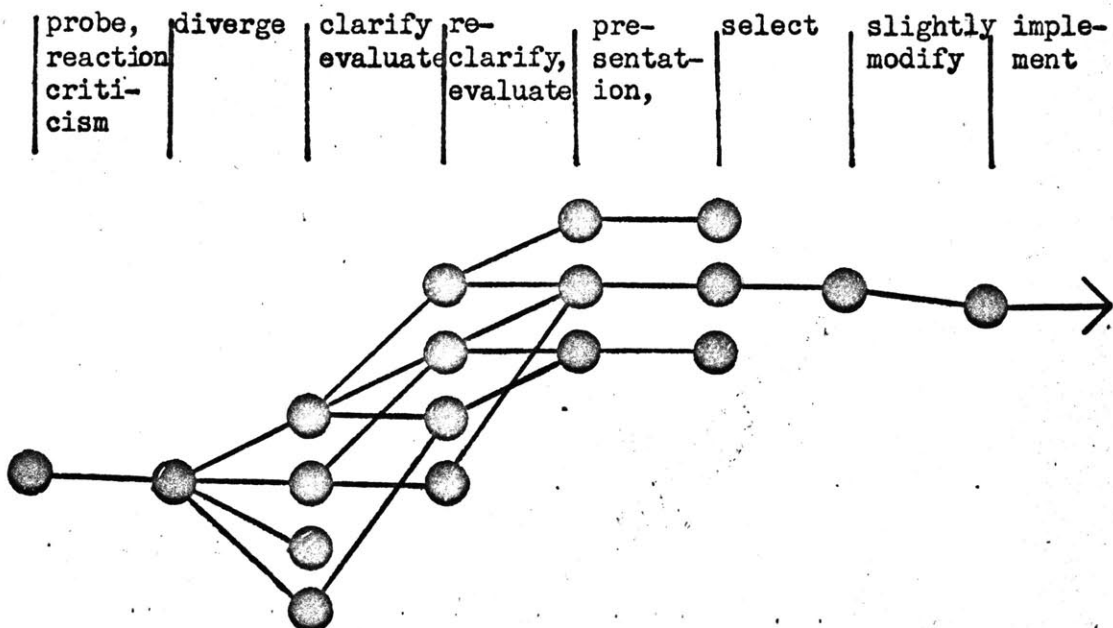
A single solution is used as a "probe" to the problem. It is used to define alternative courses of action which are a result of feedback from the client group or other decision-making body.

This process utilizes the early generation of a solution to a problem as a probe. The purpose is to seek out as soon as possible the problem definition and to draw out relevant objectives. This is possible in that the designer comes to a problem with some experience, knowledge and ideas which may be part of a first-round cycle of analysis, synthesis and evaluation as suggested by Mann.<sup>7</sup> What is important about the process is that its proper use be understood. The

solution or concept which is initially proposed is a vehicle for exploring the problem situation and not an end to be justified and buttressed.

Designers may find this process hard to use in that it reveals the designer's prejudices and also lays him open to criticism. If the right frame of mind is held throughout this process, the designer stands to gain extremely important information and feedback through the criticism and reaction. This will help clarify the objectives and give them more accurate relative importance within the system.

The reaction to the first proposal usually leads to the generation of alternative paths of investigation which are then used to further clarify, sharpen, properly weigh and possibly resolve the conflicting goals. A diagram would serve to illustrate this process.



The probe would be most useful in complex design problems where there are many variables and parameters, and where a great deal of the work is in defining the problem as to scope, goals and objectives. In the initial stages it would be used to draw from the clients thoughts about the problem. It can serve to develop and clarify the conception of the problem for both the client and the designer.

Perhaps the best design process and related techniques to use within the initial probe process may be the one which fragments the problem into subproblems and recombines solutions to these into a complete whole solution. The many components of the problem are listed as thoroughly as possible by areas, criteria, objectives. A precise record is required of the interactions and how they relate to the overall solution. This would allow many of the issues to surface as soon as possible.

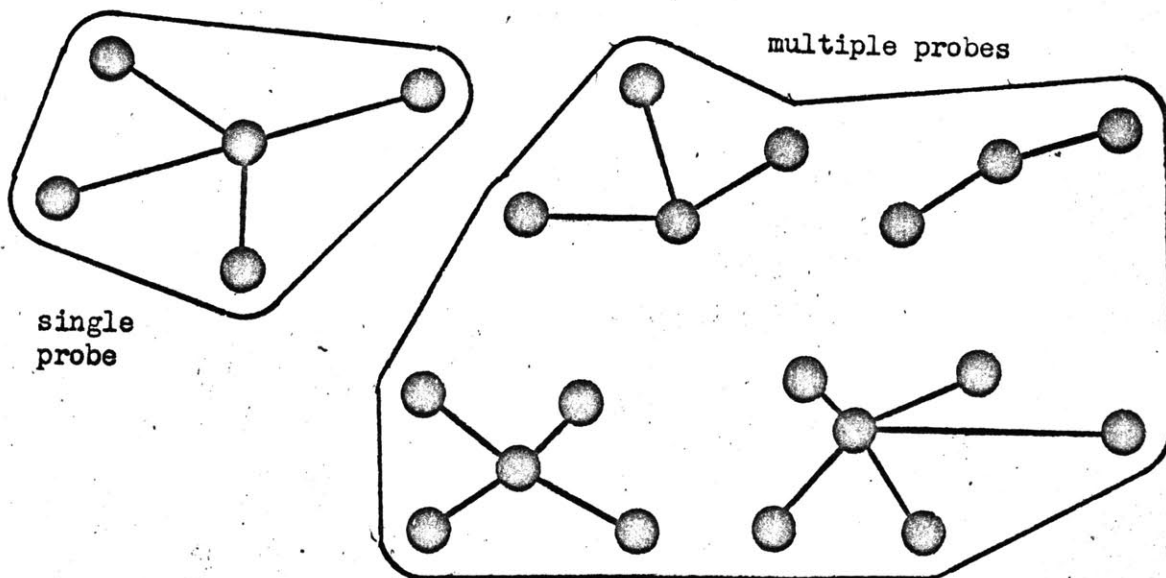
This process would be improved if resources were available to allow it to be recycled. The use of both the probe and recycling may lead to more exhaustive alternatives from which to choose. In addition, this recycling would allow jumps which may seize the new possibilities as they arise instead of following the sequential converging suggested by the process.

#### Design Process 7 (Multiple Probes)

Multiple solutions are used as multiple probes to the problem. These multiple probes are used to expand the solution realm in many directions initially, in hopes of identifying as many alternative possibilities as soon as possible. This differs from Design Process 5 in that the multiple probes diverge before they begin to converge.

This process could very well be used as a device for better defining the solution space within which a search could be conducted. It would be an improvement over the single probe in that it has the advantage of initially considering many fronts so as to get to the definition of the entire range of solution possibilities as quickly as possible. This seems to solve the objection that the single probe may overlook good solutions. The single probe may set off investigation which could eventually expand to the range which the multiple probes attained, but the multiple probes, if diverse and distinct enough, would provide a better chance for this. It would require that the initial probes be very carefully selected in the beginning. The initial probes should be as different as possible so that the solution realm is expanded much further than would occur if a cluster of only slightly different probes were presented.

The following diagrams illustrate the differences between the single probe and the multiple probes in the initial stages of the design process.



These initial probes may suggest some very unusual possibilities. It would be in the interest of a better solution to delay eliminating any of these and explore all the possibilities. If they are explored in parallel they could uncover some other directions as well as present several distinct views of the problem. When the problem becomes clearer the field can be narrowed down to a few more promising solutions for detailed development.

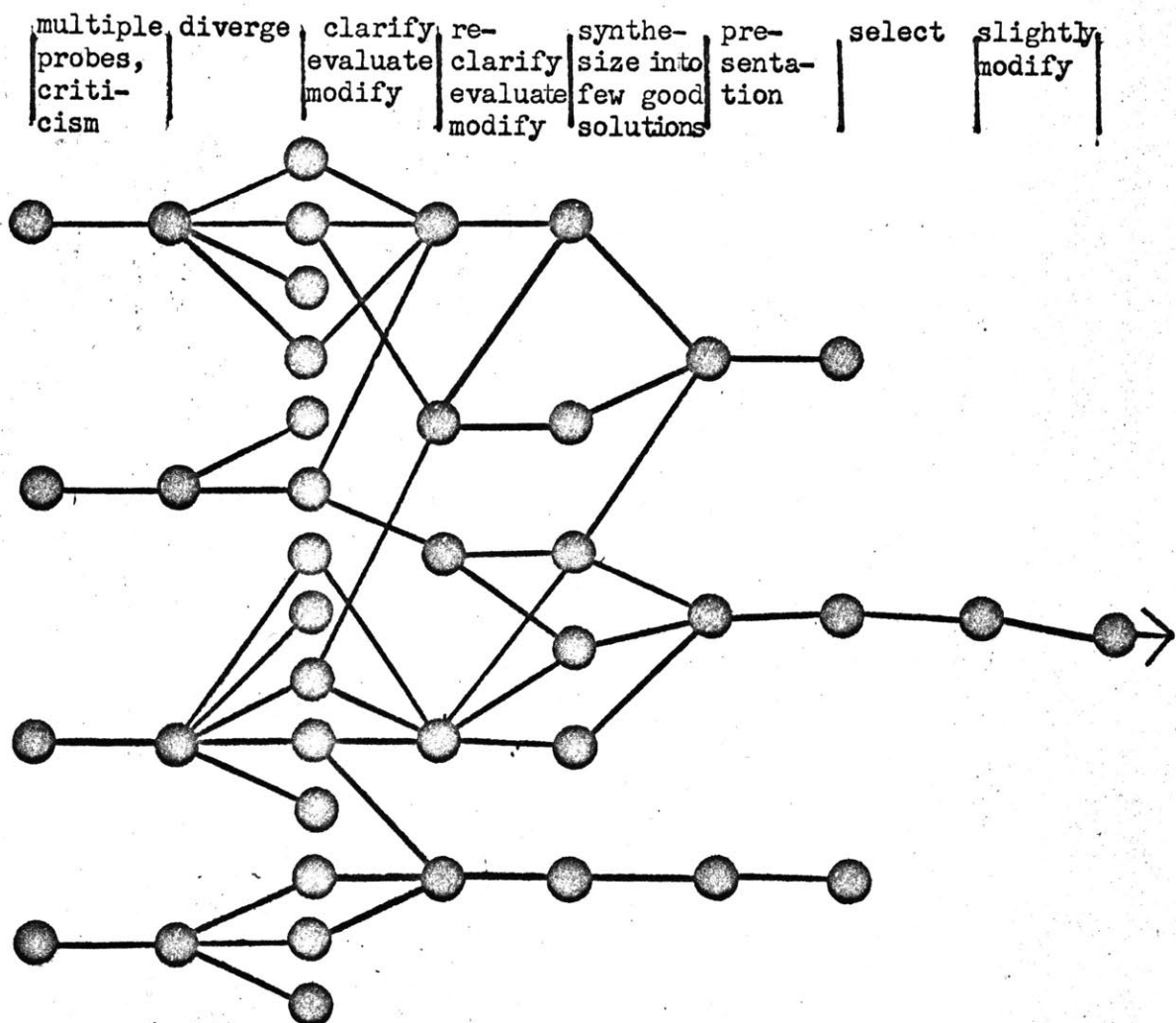
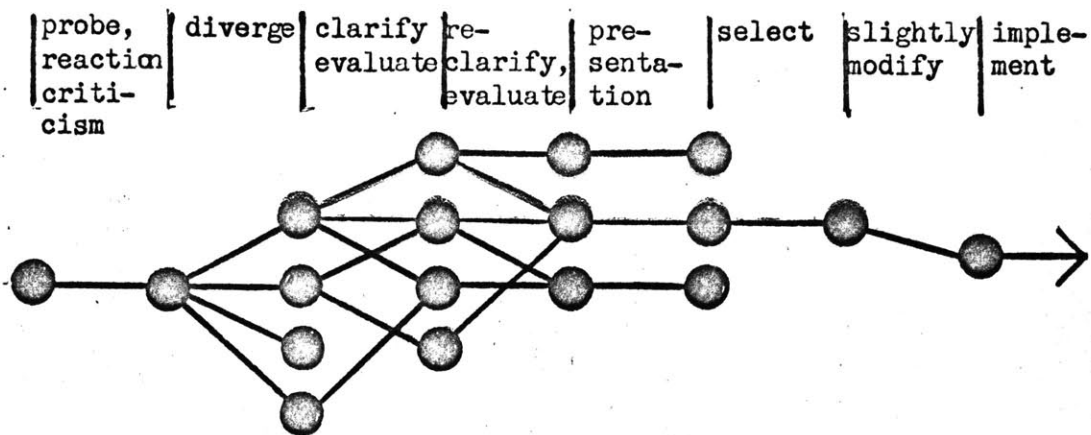
Since many initial probes are going to be discussed, there should be as part of this process a good system of recording ideas and alternative paths of investigation. If alternative ideas are added or dropped, the reasons for such decisions should be recorded. These comments could be of value later on in the evaluation and selection of more final solutions.

This design process requires vast resources which may not be justifiable or possible in most situations today. However, it would be feasible perhaps in the future when the use of machines—because of their speed, storage capacity, limitless energy and "patience"—may allow us to explore in series a broader range of alternatives very quickly. The decision-maker would be presented with a broad range of well-documented alternative solutions.

Again we have the problem of evaluation, but in a slightly different context. The client must be able to select from very many possible solutions the most adequate one for a complex problem. It seems that we are not only limited by our design processes and their design and idea techniques, but also in our processes of evaluation.



The following diagrams illustrate the difference between the single and multiple probes:



### Summary of Chapter II

In this chapter we have established relationships between the two ideal models of the continuous design process from Chapter I and the seven related design processes described in this chapter.

#### MODEL I      DEVELOPMENT OF A SINGLE SOLUTION

This ideal model of the design process has three specific design processes related to it.

Design Process 1      A single whole solution is developed sequentially, then implemented.

Design Process 2      A single whole solution is developed by fragmenting the problem and then recombining the partial solution into a whole.

Design Process 3      A single solution is developed by recycling the above two design processes until a solution is accepted.

Our conclusions were that Design Processes 1 and 2 and their related design and idea techniques could be implemented within Design Process 3.

#### MODEL II      DEVELOPMENT OF MULTIPLE ALTERNATIVE SOLUTIONS

This ideal model of the design process has four alternative specific design processes related to it.

Design Process 4      The use of competitions to generate alternatives.

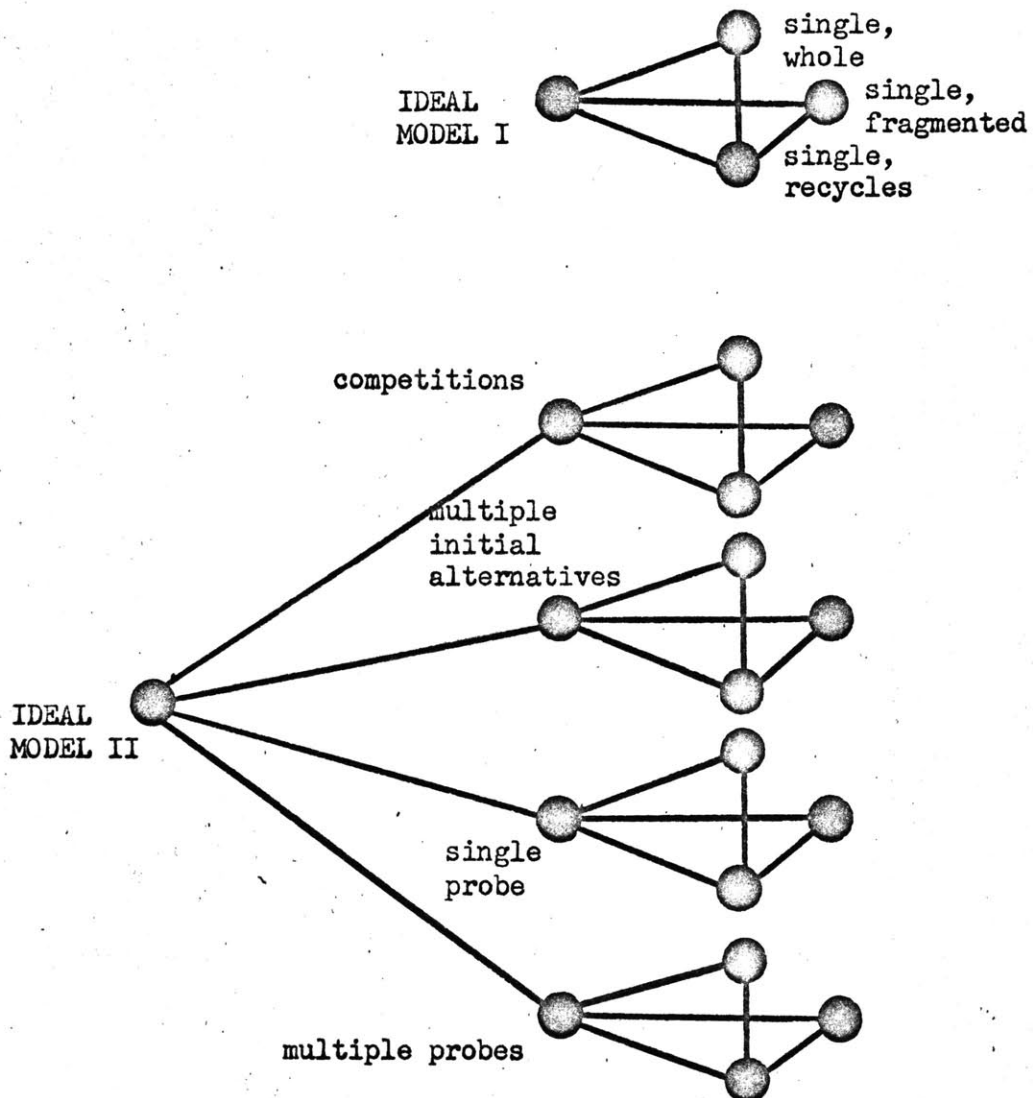
Design Process 5      Multiple alternatives suggested initially.

Design Process 6      The use of the probe to define multiple alternatives.

Design Process 7      The use of multiple probes to expand the solutions realm further.

Our conclusions in this section were that any of the design processes of Model I could be used within the four more generalized processes related to Model II.

The above relationships can be illustrated in the following way:



## CHAPTER III

### DESIGN TECHNIQUES

There are six types of design techniques which can be helpful within the seven design processes discussed in the last chapter. They are grouped by the way that they attack a design problem: adapting previous solutions, trial and error, incremental formal play, seizing the essential, disaggregating the problem into sub-problems, and growth models which are used to test the consequences of design rules without interruption. Some of these are more mechanized versions of a traditional technique of design.

### PART I

#### Design Techniques for the Incremental Generation of a Single Whole Solution--Design Process I

##### Group A      (Adapt Previous Solution)

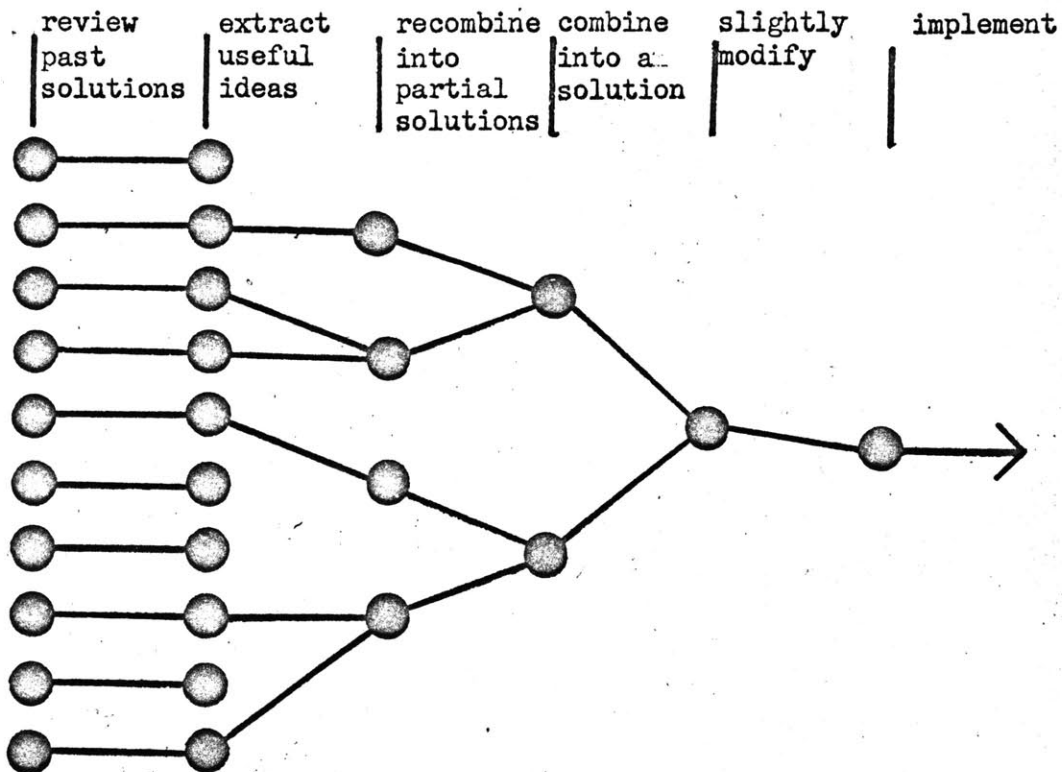
In this type of technique the designer looks to the previous designs or prototypes and selects one which seems most useful and workable for the problem at hand. Then he either applies it directly or introduces slight modifications before it is implemented.

##### 1. Adapt Previous Solutions

We may be solving problems into which others have already gained insight. In many cases a large number of previous solutions can be collected from various sources--for example, a literature review of past related work. This technique may find parts or

total solutions which may be applicable to the problem. Sometimes this review of the existing solutions and ideas stimulates new ideas for design.

Usher has referred to this as "cumulative synthesis" which is the combination of bits, parts and wholes of past ideas of design into new ideas and solutions.<sup>1</sup> The validity of this technique lies in the fact that we may be confronted with a situation where great innovation is impossible and a slight modification of what already exists is the only and safest path to follow, especially when one has little or no knowledge about the consequences of the innovation. It is suggestive of our acceptance of gradual evolution within society.



An example of this technique's recent use would be in the new town of Columbia. In the design of this project past solutions for the design of cul-de-sac and cluster development were used as well as winding suburban streets for the lower density areas. This assured the developer of a safe product. In addition, it was not too different from the surrounding area and was in the fastest growing corridor in the country. Slight modifications were incorporated to rectify some of the inadequacies of the standard suburban development. These modifications included city, village and neighborhood centers; the neighborhood stores, schools; a minibus system enabling one to move easily within the town; and the large amount of open space.

There are few good examples of past successful solutions to complex design problems which we might examine for possible future solutions. However, a review of past literature and past efforts may be very useful in outlining what we should not do. This in itself would be a valid contribution of the technique.

The lack of good past solutions and the fact that environmental needs are changing so rapidly make this technique a sort of "make-do" approach. However, we have been "making do" for so long that we are patching up the already patched versions of obsolete solutions. This technique should be employed only when the limited resources--especially time and ideas--prevent the development of a more adequate solution.

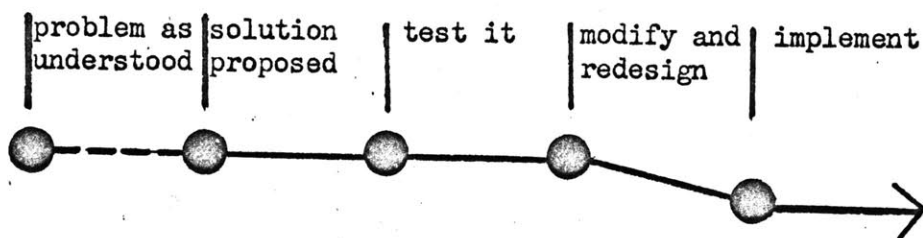
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## Group B (Trial and Error)

In these techniques the designer develops a solution, intuitively or from experience. Then the solution is tested or evaluated. Slight modifications are then introduced by redesign before it is implemented.

### 2. Trial and Error

This technique is used a great deal in structural design. The designer produces a solution, tries it out and corrects it by redesign.



For city design situations this design technique has very few strengths. It is difficult to imagine a mock-up city being tried out and scrapped if the design was a failure. The testing of even small incremental trials would be hard to conduct in this fashion because feedback is so slow, and the designer is not able to learn from his mistakes within a single project. He would be able to use the feedback information in another situation, however, if it were similar.

At the laboratory scale, the development of simulation models for complex problems would allow us to test designs for future implications. This, of course, would depend on the development of adequate simulation techniques for evaluating the performance of

possible environments. This ability, with feedback speeded up by computer simulation, will be helpful to the designer in the future.

### 3. Design by Natural Selection<sup>2</sup>

A computer program is presently being developed which can seek out a plan arrangement in which the functional interrelationships of the spaces are optimum. It is called Design by Natural Selection and is similar to the biological process from which it draws its name. The following example illustrates how this design technique works.

An extremely simple example of the mathematical model used might be that for a five-room house.

- A living room
- B dining room
- C kitchen
- D bathroom
- E bedroom

The desired interrelationship among all the elements is expressed numerically, for example:

	A	B	C	D	E
A	-	8	2	0	5
B	-	-	10	0	0
C	-	-	-	0	0
D	-	-	-	-	10
E	-	-	-	-	-

Parsons calls the numbers in this table above "pair importance values", and the number associated with any pair of elements is a measure of the importance of close proximity of those two elements. Thus the value 10, assigned to the bedroom and bath as a pair, is tantamount to demanding that they be contiguous; the same is true of the kitchen and dining room. Conversely, the relationship between the dining room and the bedroom, which is rated zero, is by implication immaterial.



A checker card would represent the plane on which the five rooms would be manipulated. The symbols representing each space are then dropped at random into some of the squares. It is possible to attach a score to each pair of elements indicating how well the arbitrary placement of the elements meets the requirements of the previously established table of interrelationships.

For example, if A and B are three squares apart, the strength of the interrelationships between the pair is eight; thus the score for that pair is the product of  $3 \times 8$  or 24. Similar scores exist for each pair of elements and the sum of all these is the score for the entire arrangement. The lower the total score, the better the arrangement.

The computer then transposes any two squares and computes the score for the new arrangement. If the new arrangement is better than the old it will be held in the computer's memory; if it is worse the pair will be returned to their original positions. The process continues: random pairs of elements are interchanged and changes that improve the floor plan survive, those that do not perish. The process is one of gradual improvement by testing the effect of small changes that give this method its resemblance to Darwin's doctrine of the survival of the fittest.

This technique is a step-by-step method which places the importance in design on finding the important relationships between activities instead of trying to concentrate on the overall concept. It requires that the constraints and objectives be made explicit in the very beginning of the process. This becomes increasingly more

difficult with our complex problems. The vast work in this technique is in identifying the variables and determining their optimal relationships. It is at this scale that the designer is also making important decisions which will dictate the final design.

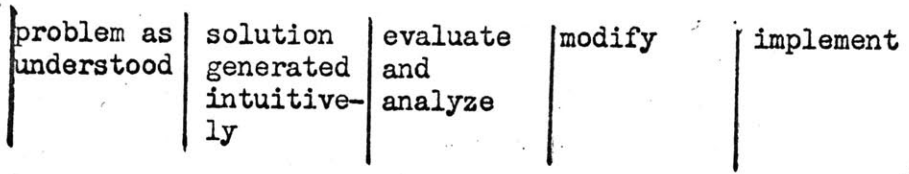
Once this has been done, the machine would seem to be performing a dull but necessary task of trial and error, trying to optimize the relationships which were dictated by the designer. The results would probably be a surprise—possibly good, possibly monstrous, depending on the thoroughness and clarity of thought given to the formulation of the relationships by the designer.

This would be a valuable technique for systematically generating alternatives if the purpose is kept clear—to explore the consequences of design rules or mathematical relationships. A limitation of this design technique is that since it is incremental it can miss better possibilities which are "jumps". It should be part of a cyclical design process.

#### 4. Experience, Intuition and Rationalization

The first step in this technique would be an intuitive leap which limits the search and obtains a short route to a "good solution". This then is analyzed and modified so that it meets the minimum criteria or performance standards of the problem.

The following diagram will serve to illustrate this technique.



The value of this technique depends on the nature and scope of the problem and on the skill and experience of the designer. A person like Pier Luigi Nervi can use this technique in construction because he has an unusual intuitive understanding of structural behavior and a great deal of experience. This suggests that the technique may be useful in the design of a structure where the design could be built, tested, evaluated and modified. This technique allows for gradual evolution by trial and error, but trial and error does not seem desirable if the design cannot be tested, especially where the consequences of failure are so high.

It is doubtful that this technique would be appropriate for complex problems until we develop good techniques for analyzing, evaluating and modifying complex designs. It could be a useful technique if the proposed design could be simulated and tested as to its performance relative to the stated objectives and performance

standards. Then the designer could modify the design so that it met at least the minimum requirements. Even so, a great fault with this modified version of the technique would be that it did not search for a more adequate solution and it would only seek to make the first proposal work (even this would be a great step in city design). It converges quickly on a solution which may be efficient in terms of time and money.

I would call this the "great-man approach" in that the designer who utilized this approach would feel that he understood the problem and could propose an adequate solution. It is this attitude that would exclude any further clarification of the problem and any extensive search for alternative solutions.

##### 5. Incremental Design Process (environmental management)

The incremental design technique may be a valuable tool to use at the scale of the city, where the consequences of actions are not well known and the pressure to do something is so great. In such a situation a design proposal would be implemented, and through a process of analysis, evaluation and modification, future increments of that same proposal would be transformed. This would be a cyclical ongoing process. It is like the trial and error techniques of the engineer which we discussed above. Its real value may be in suggesting incremental changes tried in a real situation to be accepted or rejected. If accepted, the changes would be tried at larger scales.

An extension of the above technique is suggested by Serge Bouteurline's ideas of "environmental management". He is concerned

with continuing the design process beyond the initial realization. Because we are unable to have exact knowledge of the effects of the physical environment on people it is impossible to provide optimum human environments in one attempt. He also suggests that it may not be fruitful to predict the behavior of the ultimate users, in that their patterns of behavior as well as their values will change.

Therefore, beyond the actual design and realization there should be a follow-up via environmental design which basically seeks to make minor adjustments and modifications in the environment, so that the design in fact does respond to the activities for which it was designed. The environmental manager continues to conduct minor modifications as they are needed.

The environmental manager knows most of the components in the system, how they work together, the specific users, and their specific activities. For this reason, the few decisions he makes to intervene within this system can have great value. <sup>3</sup>

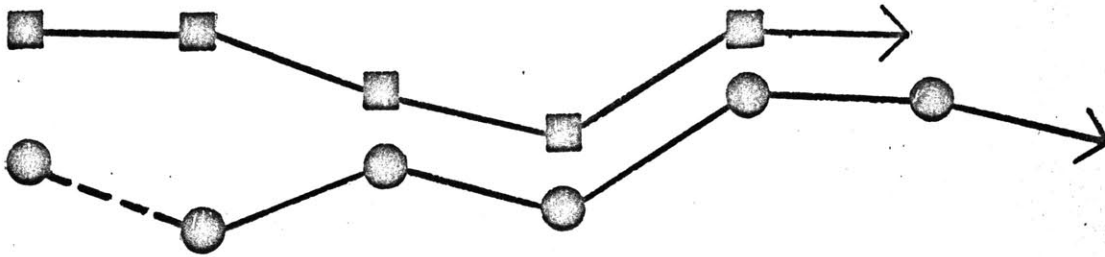
At the scale of city design this concept would involve monitoring human behavior in order to adapt the environment to new requirements. If we think into the future where we would have enough knowledge and ability to more easily adapt the environment, we might no longer have to tolerate mistakes of the past.<sup>4</sup>

The following diagram illustrates this process of design, realization, activity modification, design modification, activity modification, design modification, etc., etc.

Legend

□ environment modified

○ activity change



### Evaluation of Trial and Error Techniques

This group of techniques is related to the first process in that they are used in developing a single whole solution to a problem. The common attribute of the techniques is that they generate the solution through a process of trial and error.

If there is a short amount of design time and other resources are also limited, and a high risk is involved, the techniques of Trial and Error and Experience, Intuition and Rationalization are helpful to the city designer. They allow him to develop a solution quickly, drawing greatly on his past experience and capacity to innovate. A designer with great ability and experience, such as Nervi in structural design, could produce a good solution.

If we had a long time and greater resources at our disposal, as well as more adequate evaluation techniques, the technique Design by Natural Selection could be used to test out our designs (especially their internal relationships) prior to implementation. Since this technique presently only optimizes a system of interrelationships a method would be needed, preferably connected to this technique, which would allow us to evaluate the design produced given the interrelationships which we have initiated.

If we have a longer time and greater resources, we could utilize the technique Incremental Design Process (environmental management). This would require that we take initially high risks, but it allows us to modify our design if it does not work as predicted. This technique seems useful not only at the building scale, but also could be applicable to the city scale, or parts of it. Possibly an entire housing project could be run on an experimental basis, with modification and change as they were required. It would be very expensive to constantly change a design, but the total cost may be less than that of complete redesign. This approach could be used for a live laboratory in which we design large parts of the city which would allow us to experiment with the design of environments. These efforts could be government sponsored, and the results would be made available to other designers, builders and developers of the environment. An example of such large-scale experimentation sponsored by the federal government is the Model Cities Demonstration Program which allows new ideas to be tested and evaluated before they become part of a national program.

We should attempt to increase the usefulness of this approach, especially since the consequences of failure in urban design are so disastrous. We must develop evaluation techniques in order to better predict how well a design satisfies the stated objectives. This then should be followed by techniques for environmental management which would allow us to correct our bad assumptions as well as modify the design over time. The combined use of these techniques seems more appropriate than their use in isolation.

If the concept of trial and error is used without modification and evaluation, or if the experience and ability of the designer are limited, the risk of failure is very high. An example would be the Urban Renewal Program where an idea was tried and it failed. We have had to modify it or stop it altogether.

#### Group C (Incremental Formal Play)

In these techniques the designer develops a solution by taking a form (square, circle, pinwheel) and playing with it until a formal solution suggests itself. If no solution is discovered then that form is discarded and another one is pursued. This method is continued until a workable solution is developed.

#### 6. Incremental Formal Play

Incremental changes will be tried out which are suggested by the latent features of the original form, exaggerating, developing or systematically transforming them until an interesting possibility is uncovered. If no such possibilities appear, that line of development will be abandoned, and a new starting point will be sought. 5

In using this technique the designer latches on to a form which seems to suggest solutions to the problem. He then analyzes, modifies and develops it in a fluid way until he attains a fit between the solution and the context. Examples of this technique are the influence of forms like the pinwheel on the organizational basis of buildings such as schools, industrial buildings, etc.

In searching for formal expression to our designs we often run through a series of forms which we have used in the past. The square and rectangle are the most common. More complex are the



triangle and hexagon, and still more complex are the circle and spiral. The difficulty is in our ability to manipulate these forms in a useful, meaningful and economical way.

The designer also uses the activity of "formal play" to explore the organization of components of the problem--for example, the pinwheel to organize the square, or the line to organize forms in a linear fashion as beads on a string. At even a larger scale the process of "formal play" leads us to explore the use of grids and other nets, i.e., the "circulation net" of a city. This may include two-way nets (the square grid), three-way nets, or even three-dimensional grids such as steel office structures.

#### 7. Machine Generated Alternatives (random or controlled)

A computer could possibly be used to generate randomly combinations of a set of variables. The inputs would be constraints, a set of variables with permissible ranges, a set of objectives or minimum standards. The machine generates all of the alternatives which are within the constraints and meet the objectives. This is very much like the mental process of the designer for generating alternatives. It is a sort of random, almost kaleidoscopic kind of cross multiplying, associating process which is maximized and appears as an insight. The designer would still have to recognize the possible alternatives out of all those being randomly generated.

John Arnold has suggested that the machine might be used in the first phase of the design process in the following way:

I would program such a machine with all the information that I think is important and relevant to the problem, and then push the button and have the machine carry out all the cross-combinations and associations and give me a list of possible ideas. This could be more efficient than any group activity or individual conscious activity. 6

He then cites an instance where a large chemical company used a computer to give them a list of possible trade names.

As suggested by Lynch, most of the ideas which are machine-generated would be monstrous, because the designer may not have introduced enough information.<sup>7</sup> As an alternative strategy the designer could do a preliminary sketch problem to determine those areas of information which he felt would have bearing on the problem. He then could add additional information as it was needed.

This technique could be developed so that when the machine started to generate solutions, the designer would watch and seize the first interesting possibility. Then he would instruct the machine to shift to and pursue that possibility. Assuming that the machine has graphic output, the designer could visually explore many alternatives. If none of the possibilities which pass before the designer are worthy of further exploration, the machine would be directed to a new area of exploration and search. The strategy of the technique would be: explore, select, pursue, save for further study or reject and start again. A series of possible paths of exploration are compiled and which can be returned to again after a range is accumulated. The scanning of machine-generated solutions may trigger off other possibilities.

### Evaluation of Incremental Formal Play

The first technique, Incremental Formal Play, is related to Design Process I in that it searches for a single whole solution incrementally. Machine Generated Alternatives is a mechanized version of this technique where the designer outlines the initial constraints and then watches while the machine generates alternatives within these. He selects the first interesting possibility to further develop. If the machine does not generate an acceptable solution, the designer can change the constraints to pursue a new direction.

Because the designer works with a machine which is generating alternatives from a set of variables, the technique could be used within any of the design processes. It could be very useful within Design Process II which fragments the problem. The machine would recombine the subparts into alternatives, one or several of which could be developed.

#### Group D (Seizing the Essential)

In using this technique the designer intuitively factors out the most important element of the design situation. This element or component of the design is optimized within the design solution, and the other components are relegated to a lesser importance. These solutions are often noted for their "forcefulness" and "strength".

#### 8. Seizing the Essential

Many creative designers will "seize the essential" or simplify

a complex problem by intuitively factoring out the most important elements in the design problem.<sup>8</sup> For example, when designing a building, the designer may concentrate on arranging the horizontal circulation patterns and vertical cores (which house stairs, elevators, mechanical, etc.). The rest is considered flexible space. The rationale is that while the other parts of the building can be changed or modified, these elements do not change frequently and therefore are crucial. An example of this technique at the city scale would be David Crane's use of the "Capital Web" to structure and direct the growth of a city.

The technique seeks to optimize one characteristic whether it is the "essential" character of the terrain, the "key" symbolic expression, or the "primary" function. In a city the "essential" might be considered the movement system. The other requirements are often relegated to a secondary position. This is an intuitive way of ranking the various variables within a problem situation. The technique is a more traditional method of the new Linear Programming techniques for optimizing a single variable—for example, the cost of a complex problem.

Where this technique has been attempted at the city scale it has produced results like Brasilia. The planners did not attempt to resolve all of the problems (social, political, economic) which would be encountered in its development. Instead they chose to optimize the symbolic importance.

Although this technique is not adequate for handling complex problems, it may be useful as part of a more general process where

it is one of several strategies which are used to generate alternative solutions to a problem. The technique would be utilized as a search device instead of in its present overly deterministic role.

## PART II

### Design Techniques for Developing a Single Solution by Fragmenting the Problem into Subproblems--Design Process II

#### Group E (Fragmenting the Problem)

In using these techniques the designer disaggregates the problem into pieces by either areas, activities or criteria. Interrelations are identified among the pieces and these form subproblems of the whole system. Solutions are suggested for each of these subproblems, and these are combined into a single whole solution.

#### 9. Systematic Design Method 9

The essentials of this method are: to break the problem into pieces; to solve each piece by itself; and to combine the new pieces into a whole.

Alexander's one-step decomposition and precise recombination technique is similar to this technique, but there are some important differences. Alexander is concerned with synthesizing the bits and pieces into a whole so that the solution reflects the multiple goals and objectives. This technique, as proposed by Archer, gives an exhaustive routine for organizing information and conducting a rigorous search for solutions. It does not specify a procedure for recombining the subsystems into a solution.

Archer's technique is borrowed from computer techniques for the assessment of design problems and the making of design decisions in the face of conflicting requirements. Resolving a large number of subproblems and listing all the combinations and permutations of the partial solutions is the very thing computers do well. But this process does not require that the computer be used. Even if a computer is used the designer must do steps 1 and 4.

The technique has six stages:

1. The aims and objectives of the design effort are determined together with the essential criteria by which a good solution will be distinguished from a "not-so-good" solution.
2. The factors effecting the design are identified and listed.
3. The ways in which factors depend upon or interact with one another are established. Pairs or groups of interacting variables are designated "subproblems".
4. The factors or subproblems are arranged in an order of priority to indicate which pair of subproblems should take precedence if it should prove impractical to provide the "best" solution to one subproblem (i.e., the best component material for durability purposes) at the same time as the "best" solution to another subproblem.
5. In view of the consequences of each decision in turn, the amount of effort to be put into the working out of each subproblem is determined, and each subproblem is dealt

with by appropriate means. One of the problems might be to decide how far the need for innovation should be taken.

6. Finally the whole design problem is expressed as a rank ordered list of attributes (see Attribute Listing--Crawford) which the final solution is required to have.

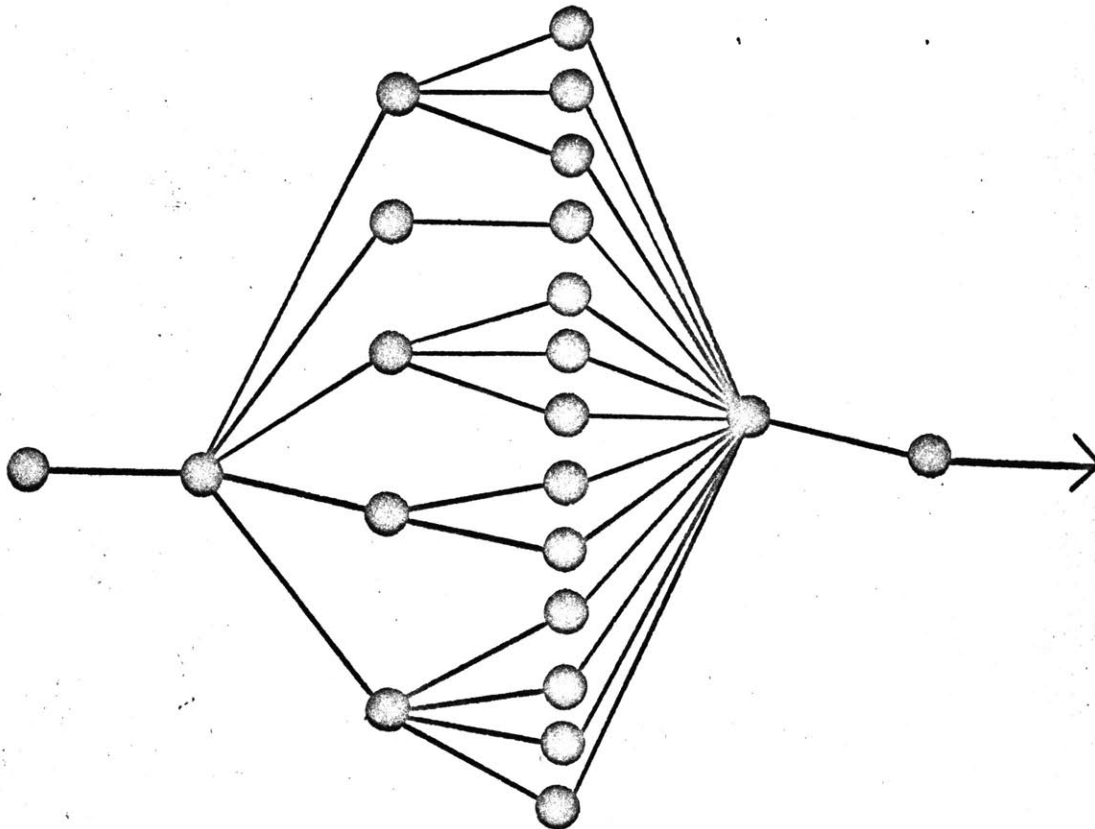
The important advantages of this routine are the following:

1. As much data as possible is sought.
2. The whole design problem is divided into a number of distinct subproblems, making it more manageable.
3. The subproblems which are related to matters of fact are separated from those which relate to value judgement.
4. The act of rank ordering and priority giving is clearly made, if useful or possible.
5. The thresholds of decisions are defined.

At this crucial point it is unlikely that the computer will be able to replace the designer in the role of judgement, decision-maker, or idea generator. There still remains the task of proposing an apt and original overall solution, which can then be tested and evaluated according to the objectives of the problem.

The following diagram will illustrate how this technique functions throughout the design process.

identify and define problem	fragment the problem into parts	decompose further, seek solu- tions for subproblems	recombine partial solutions into a solution	slightly modify	implement
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This technique is a very good means of setting out a problem in a systematic and logical way. It is possible that in its process of preparing a problem, the solution may become obvious to the designer. For lesser problems, these routines (see Archer Check List, Appendix D) which are worked out for rigorous analysis may act as a check list of procedures which the designer must carry out however intuitively. The value of these check-lists is in helping assure



that everything is taken into account.

The most important feature of the systematic method for design (which really is a method for handling information) is that it permits a widening area of search for interpretations of the problem and solutions to it. This fragmentary treatment of the design problem is in contrast to the development of overall concepts which many consider to be the basis of design.

The method of recombining the subsolutions into an overall solution is not made explicit. Archer offers a check list as an analysis of the designer's position at this "threshold" where the designer must develop a solution. He outlines the possible lines of action which he suggests take place in complex problems involving many variables. Archer feels that the creative act of 'designing can not be specifically prescribed.

#### 10. Look for Clues in the Apparent Structure of the Problem

The difficulties in a complex design stem from the inability of the human designer to manipulate simultaneously a large number of interacting design relationships. In the following technique the analysis (decomposition) of the design problem is based on the inherent structure of the problem and presents a direction of attack for the synthesis of a form.

10

This technique decomposes the problem to a manageable size. It is done in a one-step decomposition of the whole problem into its subparts by means of listing exhaustively as many of the primary objectives and standards as possible, instead of just listing the

major ones. These are broken down into many subparts such as number of low income families in temporary shelters, number of square feet per pupil, etc.

Single optimum solutions are sought for each sub-objective by "seizing the essential". Each partial solution is then confronted with another partial solution and their conflicts are resolved into another partial solution. The design proceeds step by step in this manner through a whole "tree" of decisions which began with numerous partial solutions and ends with a single whole solution. This final solution should reflect the multiple goals and standards of the problem situation, which were considered at each decision point.

The order in which the pairs of solutions are confronted with each other is crucial because a different order produces a different solution. This technique deals with the strongest conflicts first, and the resulting group solutions are relatively independent of each other when the final stages are reached. This may not be the best order because a multitude of lesser objectives are compromised early. A computer program has been written for this binary decomposition named HIDECS 2. <sup>11</sup>

Because you relate each of the subobjectives back to a basic objective and then to the total problem there is no interaction among the smallest parts. This restricts the solution to the way in which it is initially viewed. Attempts have been made to interrelate the subobjectives at the smallest scale (HIDECS 3). <sup>12</sup>

### Evaluation of Fragmenting the Problem

These two techniques are related to Design Process 2. They develop a single solution by fragmenting the problem into its parts, then solving for the independent parts. The separate solutions are combined into a single whole solution.

These techniques require the designer to be precise in defining the various components of the problem. Their main contribution is a bookkeeping system for filing the many variables of a complex problem situation. The designer can, if enough resources are available, rigorously study the problem situation so that he may be able to propose a solution cognizant of the real problems.

The city designer can use this technique in its present form only in a limited sense. By disaggregating the problem into components, the designer may better understand the relationships of all the understood variables. This would have to be supplemented with a constant updating of the latest developments--the use of the technique would have to allow for new information.

The design time would very likely be long because of the investigation and collection of a great number of facts. The project could take a narrow scope and go into great detail, or a wider scope with less detail. Some selection has to be made in the initial stages to limit the amount of data that would have to be processed.

Several modifications could improve the use of this technique. Instead of recombining into only one solution, it could be used to develop parallel alternatives so that they could be compared and evaluated. This technique could also be used in different degrees

of detail throughout the entire design process. It would seem questionable if you could use this cyclically.

### PART III

#### Design Technique for Developing a Single Solution by Recycling

#### Until a Solution is Found Acceptable--Design Process III

#### Group F (Growth Models, Gaming)

This last group of design techniques can be used by the designer in testing his designs or the implications of design decisions into the future. In these techniques assumptions are made about future decisions, behavior, population, economic trends, policies, etc. A simulation model or gaming is used to explore the implications. If the anticipated results are not attained, then the policies are modified until a fit is achieved.

#### 11. Growth Models

Growth models which make assumptions about decision, behavior, forecasts of population and economic trends are also used to test out the implications of policy assumptions. If the policies do not produce the anticipated results, they are modified until they fit. These models could be used to generate many future alternatives by varying the ingredients--public actions and the assumptions as to the future trends of growth. In doing so the costs and benefits of the various alternatives can be compared. It has even been suggested that these models could be run backwards from a future desired state to determine what actions would be needed for that future state.

Such an approach conceives of the urban complex as a phenomenon to be explained scientifically and as a changing configuration that can be predicted in the same way that the solar system can be predicted from the applied theory of physics. Indeed, such an approach is well designated as applied social physics. The philosophy underlying this approach is the natural result of the direct transfer of the methodology of the physical sciences.<sup>13</sup>

Growth models are useful in the generation of alternative solutions, and for the analysis, optimization and evaluation of the alternatives. They can also be used to test hypotheses which are not amenable to analysis.

## 12. Gaming Techniques--"Trade-Off"

An example of gaming as a design technique is "Trade-Off", a community involvement device used in one city of the Model Cities program.<sup>14</sup> "Trade-Off" has been played by professionals, both separately and together. First, community needs are stated in a situation prospectus. Then the players are asked to build the best community. This may be done on a grid system laid out on a board using small wooden blocks to represent physical elements. It has also been suggested that the game be played on a blocked-off street in the neighborhood by laying out the grid system (an abstraction of the site) on the street itself, and using large styrofoam blocks to denote the physical improvements suggested by the situation prospectus. Each physical component may have a price tag, or the entire community may be priced out component by component after the city is laid out. If the price tag for the community is more than is available, the players are asked to assign priorities to the various components.

This game was invented to help professionals from the outside

to understand neighborhood values and goals, and help neighborhood residents learn more about problems faced by professionals. More important, they help to create neighborhood interest and above all can lead to community involvement in planning and decision making.

The strengths of this technique are as a vehicle for drawing out objectives and goals which have previously not surfaced. Gaming can be used in simple or complex problems. It is unable, because of its organization--you are always working within the original definition of the problem--unable to expand the solution realm. This technique focuses usually on the immediate concerns of the local residents and makes no allowance for the outside change agents to introduce radical changes after the initial step. In this case it is used in monitoring local needs and desires while at the same time eliciting local participation and backing for any agreed-upon plan of action.

At the complex scale a group of professionals would vie with each other in trying to get the best possible plan given a limited amount of available resources. This group may be a simulation of a city decision-making body--mayor, planner, etc. The participants in gaming would weigh the importance of their objectives and participate in a complex trade-off process, trying to make the best possible use of their resources.

#### Evaluation of Growth Models

These techniques are related to Design Process 3 in that they propose strategies or designs, expecting them to be rejected. They are recycled again and again until an acceptable solution is

developed.

These design techniques are useful to the designer in exploring the consequences of his design and design strategies. They should be used as part of a larger design process parallel with other design techniques in a cyclic fashion to allow a repeated monitoring of the changing goals of the client, as well as the changing design situation.

#### PART IV

##### Design Techniques for Developing Multiple Alternative Solutions--Design Processes IV, V, VI, VII

Design Processes 4, 5, 6, and 7 can use any of the design techniques related to Design Processes 1, 2 and 3 in the simultaneous generation of multiple alternatives. Individual techniques can be used to generate the individual solutions simultaneously.

### Summary of Chapter III

In this chapter we have established the following relationships between the seven design processes and the twelve design techniques.

#### Design Process 1      Incremental Generation of a Single Whole Solution

##### Group A--Adapt Previous Solutions

1. Adapt Previous Solutions

##### Group B--Trial and Error

2. Trial and Error
3. Design by Natural Selection
4. Experience, Intuition and Rationalization
5. Incremental Design Process

##### Group C--Incremental Formal Play

6. Incremental Formal Play
7. Machine Generated Alternatives

##### Group D--Seizing the Essential

8. Seizing the Essential

#### Design Process 2      Developing a Single Solution by Fragmenting the Problem into Subproblems

##### Group E--Fragmenting the Problem

9. Systematic Design Method -Archer
10. Look for Clues in the Apparent Structure of the Problem  
-Alexander

#### Design Process 3      Developing a Single Solution by Recycling Until a Solution is Found Acceptable



## Group F--Growth Models

## 11. Growth Models

## 12. Gaming Techniques--"Trade-Off"

<u>Design Process 4</u>	Competitions
<u>Design Process 5</u>	Multiple Alternatives Suggested Initially
<u>Design Process 6</u>	State and Develop a "Probe"
<u>Design Process 7</u>	State and Develop "Multiple Probes"

We concluded that any of the design techniques related to Design Process 1, 2, or 3 could be used to develop simultaneously the individual solutions.

In this chapter we have been concerned with developing the capacity to technically help the designer handle complex problems. This search for more adequate methods has exposed us to existing and proposed design techniques. Most of these design techniques attempt to define the problem and organize the data. Machines are being developed to help cope with the increasingly complex problems, yet they only bring the designer to the threshold of the creative action. The man-machine partnerships require that the designer bring to this symbiotic relationship the very thing the machine can not presently provide--creative ideas: ideas which respond to the problem situation, ideas which can then be tested as to their consequences.

There is no escape for the designer from the task of getting his own ideas. After all, if the solution to a problem arises automatically and inevitably from the interaction of data, then the problem is not by definition a design problem. 15

We must not concentrate on developing design techniques to the extent of neglecting the other half of new and potentially powerful partnership. How can the human designer be stimulated into producing creative and meaningful ideas? The next chapter will be concerned with a cross-section of methods which are used to stimulate creativity. These individual and group methods are used to systematically generate ideas for the problem situations.

## CHAPTER IV

### IDEA TECHNIQUES

During a visit to a small island, one of the authors had occasion to discuss the problems of future development with its administrator, who remarked,

'This island has been examined by every type of expert, including economists, sociologists, engineers, political scientists, anthropologists, and geographers. They have all told us what our problem is and they have all told us how to measure and evaluate our actions. But our trouble is we have no actions to analyze or possible successes to measure.'

The designer who has not progressed beyond the problem statement is in a similar position to the island administrator. He has come to the core of the design problem. He needs an idea.

When he has generated alternatives which suggest solutions, he can test for feasibility, analyze, optimize, and build. It is at this point in the problem that he either does or does not create the ideas. Subsequently, work will verify, sort out, eliminate, adjust or expand, but all this work is dependent for its effectiveness upon solutions conceived now. 1

This chapter outlines different idea-generating techniques which can be used at the same or at different stages as the design techniques within the different design processes. These are used within the seven broad general design processes, either in the initial idea-generating stage, or as some suggest, they can be used throughout the design process whenever the designer gets stuck or is in need of further ideas, even as the design proceeds to more specific and detailed stages.

These are not suggested as replacements for the design techniques, but are meant to complement them in the total process involved in the generation of alternative solutions. These idea-generating techniques in most cases are helpful in outlining directions of search for broad ideas or concepts, which are further developed utilizing the design techniques.

These idea-stimulating techniques can be grouped into three general classes by the ways in which they stimulate ideas: (1) through free association, (2) interaction techniques, or (3) check lists. The three groups will be discussed and related to the design processes and their related design techniques.

#### Operational Techniques for Stimulating Creative Ideas

An operational technique is a system, procedure or method which enables an individual or group to produce a large quantity of original ideas with the hope that one or more may be useful. These techniques are designed to help the user overcome obstacles to creative thinking.

Most of these techniques rely on two basic principles:<sup>2</sup>

1. All judgement or evaluation is eliminated from the idea-producing stage.

2. All ideas, even the most impractical, are considered.

These two principles must be followed if successful results are to be attained from these operational techniques. The first principle allows for maximum accumulation of ideas for consideration and prevents the premature death of a potentially good idea before it could be considered. The entire efforts of the group or individual are directed at searching for and suggesting new ideas, without the limiting effects of evaluation and criticism. Because the number of ideas produced is great, the chance is increased that a creative solution would emerge.

The second principle is just as important. It encourages a person to range far and wide, to explore new ideas and is aimed at eliminating some of the barriers that too often restrict our thought process. By permitting all ideas a person expresses thoughts which he might otherwise withhold for fear of ridicule. These ideas may be useful in themselves or they may merely spark other ideas.

#### Free Association Techniques

This group is characterized by free associations developed between a group of different individuals. They may also be diverged from associations which groups or individuals get from visual or other analogies.

## 1. Brainstorming

This is the brash, Madison Avenue technique devised by Alex Osborn. The intention is that the members of a group--from 5 to 12--vie with each other in generating a rapid succession of ideas. The leader directs the group to suggest solutions to a stated problem. Some simple rules have been developed for the leader to follow in assuring a successful session.<sup>3</sup>

State the problem as simply as possible.

Rule out judgement. In a formal session, the leader should stop any member who offers an evaluation. Evaluation must wait.

Have members mention all ideas. The wilder the idea the better. It is usually easier to tame down an idea than to build it up. Someone else may suggest a change which makes a previously impractical idea successful.

Encourage members to give as many ideas as possible.

To vary the pace, encourage humor to relax the participants.

Limit the session time to a period stipulated at the beginning.

Assign a recorder to take down the gist of the idea and the originator's name on a blackboard or large chart pad in front of the participants.

Keep the list of ideas in front of the participants during the session.

Write up the ideas carefully after the session and send them to each participant. Encourage them to jot down others during the following two or three days.

Summarize the total output of ideas, grouping them under logical headings. Normally major headings are the basic design-concepts.

The brainstorming session usually should produce a long list of potential idea solutions, usually eight or nine per participant. They should be carefully documented and summarized in preparation for

evaluation. These are then assessed by those who had no part in the original brainstorming.

What brainstorming does is provide an environment for the production of many ideas. After the obvious ideas are exhausted, new ideas, adaptations, combinations, rearrangements come forth. A brainstorming session is most helpful when fresh ideas are needed or because nothing brought up so far seems acceptable.

Brainstorming works best on specific and limited, but open-ended questions. It is not intended to give final solutions or ideas which can be immediately implemented, but rather it produces ideas which might lead to a final solution. Much of the success of brainstorming depends on leadership. Difficulties may arise if the group is asked to rework old problems. With familiar problems the group may simply restate old attitudes. While groups produce more ideas than the average individual, it has not been proved that the number of excellent ideas is larger for groups than for individuals. 4 Another weakness is when it is applied to highly technical problems. Because of the effort of evaluation it is better to have a few good solutions than many.

Yet the brainstorming technique can be useful to the city designer. It does provide a way of establishing a list of things to consider which enables him to look at the problem from a broad base in the beginning stages of the design.

It would be interesting to utilize the brainstorming technique, slightly modified as a form of public debate where the residents of an area (or representatives) were to help define the problem as well

as participate in the selection of a final solution. Often the real experts in a community are its residents, and they could certainly contribute to the "complete list" which is sought by brainstorming.

### Variations of Brainstorming

#### Phillips 66 Buzz Session<sup>5</sup>

A very large group is divided up into smaller groups. Each small group elects a chairman and "brainstorms" the problem for five minutes. A single best idea is selected to present to the entire group when it reconvenes. Any evaluation is held until another session.

This modification of brainstorming was developed to use all the minds of a large group to get many possible ideas. The small group allows many people to express themselves who would not contribute in a larger group. At the same time people are being instructed in the use of brainstorming techniques.

#### Tear-Down Technique<sup>6</sup>

The object of this approach is to think of all the possible limitations or failings of a specific product. Brainstorming rules apply and after the initial session, the long list of weaknesses is analyzed for making improvements and corrections.

#### Individual Brainstorming<sup>7</sup>

While brainstorming is normally considered a group technique, it could be used by an individual if he can restrain judgement and critical thinking while concentrating on finding new design concepts.



Parnes has stated that his research provides evidence that the individuals working alone often accumulate more and better ideas than when they are working in a group.

### Brainstorming and Evaluation

In this technique a group is used in the initial evaluation of ideas as well as in the generation of ideas. Although the responsible designer makes the final decision on a design concept, a group can participate in the series of innovation and evaluation activities involved. This approach is justifiable in complex design problems where the ideas and experiences of a group are desirable and in fact necessary.

If the designer has a problem and seeks group help in generating potential ideas and design concepts, as well as providing for their initial evaluation, he can choose from five to ten associates whose total experience and knowledge includes recognized creative ability and seasoned judgement in similar design problems. The following is an outline for the procedures of a brainstorming and evaluation session.<sup>8</sup>

#### Statement of design problem

The group leader first states the design problem including the known requirements. A written statement should be provided each participant if possible. Questions and discussion are carried on until the participants are satisfied they understand the problem. The problem statement may be modified.

#### Brainstorm

The group is then taken through a brainstorm session. Be sure that each group member feels free to suggest ideas without concern for critical reactions from others. Others should

build on ideas as they are suggested. The group leader should keep the discussion free-flowing and not allow it to bog down in details of one possible solution. Suggested ideas are then listed in short form on a large flip chart or blackboard by the leader and one or more assistants. The leader should participate in offering ideas during lagging periods of the session in order to restimulate the group.

#### Preliminary evaluation

The group members work individually or in small groups as assigned by the session leader. Each member or team should furnish three to five solutions, in addition to the evaluation criteria used.

Although this evaluation process may be imperfect, conceptual ideas must be evaluated subjectively until the number of potential solutions is narrowed sufficiently to allow a thorough objective evaluation within the scope of the available resources.

The leader and assistants then write out chosen selections and the list of evaluation criteria in preparation for reconvening the whole group. Some mechanisms may require sketches at this stage, while other design concepts may be explained in words.

#### Idea-building on selected design concepts

The group is reconvened for the purpose of improving the evaluation criteria and recommended solutions. First, the list of evaluation criteria is reviewed and refined by the group. Then each individual or team presents potential solutions and the group provides ideas for improvement in a second brainstorm. The group leader then summarizes the evaluation criteria and all the recommended design concepts in their improved form on the flip charts or blackboards.

#### Final evaluation

Each member then reviews all proposed solutions and selects one approach that seems best to meet all requirements, and another as first alternate. The decision table<sup>9</sup> is helpful in this evaluation. Each member is encouraged to make a decision table and rough sketches of the design concepts chosen.

#### Group review

The group meets for a final review of all design sketches and decision tables. Copies of each are exchanged and discussed.

Each group member then modifies his design sketches and decision table and turns them in to the group leader.

#### Final report

The group leader and assistant then integrate the individual evaluations into one comprehensive decision table which rationalizes the several recommended solutions. This, together with the individual sketches constitutes the final report.

#### Follow-up

A copy of the final report should be given to each group-member for his further comments. The group leader collects these reports after review and uses them in the final judgments of the design concept selected.

In this method a period of time may be allowed between steps. For an important problem, preliminary analysis and tests may be carried out before reconvening the group for the next step. On less complex problems where evaluation is straightforward, the whole process can be completed in one session.

## 2. Synectics 10

In contrast to brainstorming, synectics on the whole is a quiet contemplative activity in which ideas are generated in a purposeful way and then are evaluated as far as possible during the session itself.

This technique has two phases. The first phase is the idea-conception phase, during which the idea for a problem is evolved. For example, one problem was to develop a lawn mower. The problem that the leader presented to the group was: "The question today is separation". As the discussion progresses the leader watches for opportunities to narrow and guide it. In the second phase the specific ideas are developed.

The chairman of the synectics session introduces the problem and asks "evocative questions" which will force answers in terms of analogies. The types of analogies used are:

1. Personal analogy. The designer identifies himself with the object in design, for example, "I am a very still lake"
2. Direct analogy. The problem is compared with known facts in another branch of art, science or technology. Circulation systems can be compared with veins in a leaf.
3. Symbolic analogy. The designer tries to penetrate to the essence or special meaning which he attaches to the problem by means of some personal symbol. This may be verbal, visual or some other form. For example, "strain".

Once a fruitful analogy has been generated, its implications are examined in detail. Like all creative acts, a synectics session is cyclic. If no viewpoint can be established from the chosen analogy, the chairman will guide the discussion back to an earlier phase.

Gordon discusses several problems and makes suggestions: <sup>11</sup>

1. The group may be inhibited by fear of being too impractical. This fear must be eliminated, which of course implies that no restrictions be placed on the actions of the group.
2. While some fatigue aids in breaking superficial rationalization so that free associations can take place, over-fatigue needs to be recognized and relief given.
3. The problem should be stated very clearly in non-technical terms.

4. The choice of a director is crucial. He must be able to both stimulate and guide the group.

5. Groups of highly specialized individuals should be avoided.

In the initial stages synectics is similar to brainstorming, except the leader is structuring the discussion to a greater degree. In the second phase of synectics the technique actually becomes a design technique in that ideas are developed.

### 3. Visual Analogy

This technique grew out of using pictures to communicate with slum dwellers.<sup>12</sup> Now it is being used as a group activity to bring out ideas for solving a problem situation. First a clear problem statement is made. Then the group--from five to twelve people--collects pictures of visual patterns from magazines, newspapers, etc. which are placed on a wall. They can collect anything they like, and it need not be related to any subject matter. They should end up with a wide imagery of culture as seen through the eyes of individuals in the group, a device which can be used for generating ideas that might suggest solutions to the problem.

Each person in the group gets a different set of colored tacks, and without too much deliberation begins sticking tacks into pictures which suggest ideas about a possible solution. After the whole group has placed all the tacks (about three minutes) each person explains to the group what the pictures with his tacks suggested to him.

This process should wrench out ideas which the group has on the problem in a short time. It also exposes different ways of thinking about the problem. Because it exposes an individual's likes or

dislikes, criticism should be limited.

It has been suggested that participants interpret each other's pictures or all the pictures which seem pertinent. Other devices than pictures can be used. In many respects this resembles the use of check lists, only here we use pictures. We might also use total environments, such as walking people through a project site and then a different environment. Differences and similarities might be listed.

This technique should not be viewed as a "last-resort" method of generating ideas in a complex decision-making situation. It could be used several times during the design process, especially if a group or individual is in a bind. If developed and used correctly it could be easy to use, and even a pleasure to use if inhibitions are broken down.

The result of this type of session will be a long list of interesting ideas and patterns. There is no mechanism within this technique for synthesizing from all of these ideas a concept that would be an answer to the problem. Its important implications are the intensification of visual--not verbal--stimuli for triggering off ideas for a problem situation.

#### 4. The CNB Method

The CNB method--Collective Notebook Method-- assumes, as do brainstorming and synectics, a group of competent men who understand the purpose of the project and who agree to cooperate.<sup>13</sup>

The procedure is:

1. In the participating group each man receives a notebook in the front of which is printed:

- a. A problem of major scope.
  - b. A very broad-front presentation of preparative material, including a variety of creative aids.
2. Each man records in his notebook, one to several times a day, his thoughts and ideas on the problem for a period of a month. Then he summarizes:
  - a. His best idea of the problem.
  - b. His suggestions for fruitful directions to explore in regard to the problem.
  - c. Other new ideas, aside from the main problem.
3. At a specified time each man hands the book to the coordinator.
4. The material in the notebooks is carefully studied and correlated by a coordinator ... skilled in organizing and summarizing such a mass of material. He gives full time to this study, prepares a detailed summary, which credits those especially deserving it ...
5. All participants can see all the notebooks after summarization.
6. A final discussion of any adequate length is held by all the participants, if desired.

This technique is useful in complex problems of great scope which may involve a long design time. It is a more thorough process than such techniques as brainstorming, because ideas are gathered over a long period of time. The individual is directed to search for pertinent material and systematically consider the variables. While the technique capitalizes on individual effort, it also draws them into a larger group effort. The city designer could use this in redefining the problem and in generating more detailed ideas.

## 5. Bionics

Nature is a good source of design ideas. This technique is based on having a knowledge of nature's means of performing a

function, which may lead to a design concept. Bionics is a very good illustration of how science has made a powerful use of studying analogous situations in nature. Bionics seeks <sup>14</sup>

to incorporate in man-made systems such characteristics of living things as self-adaptability, learning, self-organization, self-optimization and recognition. They hope that their approach will make possible the design of machines, vehicles and systems with greater reliability, sensitivity, selectivity, strength, maneuverability, speed and acceleration with reduced size, weight and power requirements.

We may have a problem which calls for adaptability, growth forms or flexibility. The study of how nature struggles with these same problems may ignite some very useful design concepts. For example, cellular growth or the circulation systems of plants and humans may trigger off ideas about growth forms and circulation systems in design situations. It would be useful to keep a list of nature's attributes which might be helpful in design.

Technology also displays images which may help us visualize or resolve a problem. For example, the force diagrams on a plate of steel or a magnetic field may suggest possibilities for circulation systems. Analogies from nature and technology may trigger off some interesting ideas, but we must be careful not to force-fit the human beings for whom we are designing. Instead, we should seek those physical forms which are expressive of and reinforce the desires and behavioral patterns which exist.

#### Evaluation of the Free-Association Techniques

Most of the individual idea techniques within the free-association group are useful in generating an idea for a single, whole



solution for a problem. Individual brainstorming or bionics seem least demanding in terms of resources than the more organized groups. However, if there are sufficient resources it would be best to use the group techniques in that they would bring more backgrounds and expertise to bear on the problem.

While most useful in developing a single, whole solution, the free-association techniques can also be used in identifying alternative ideas which can then be developed in parallel within one or several of the first three design processes and their related individual design techniques. Brainstorming could be employed in purposefully trying to identify several alternative ideas to be developed by using the individual design techniques associated with Design Processes 1, 2, 3 in parallel. Synectics might be stopped short and only yield general concepts which then could be developed in parallel instead of converging to a single solution. Separate sessions could be used where alternative ideas and solutions would be developed.

The CNB method could also be adapted. The separate notebooks might include alternative ideas which would be developed in parallel by the individuals participating in the problem. This would be similar to the dispersed team approach or group competitions where individuals developed alternative ideas which were later evaluated.

Without adaptation this group of idea techniques seems to be most useful in the development of a single whole solution which is the realm of Design Process 1, and can be used in a recurrent manner within Design Process 3. These in turn can be used within the other design processes. Its use depends on whether the aim is to develop

a single, one-shot solution (Design Process 4, Competitions; Design Process 6, the Single Probe), or single solutions in parallel (Design Process 5, Multiple Alternatives; Design Process 7, Multiple Probes).

### Analytical and Interaction Techniques

This group is characterized by a step-by-step approach. These techniques rely on a thorough and logical attack on the problem and its various elements. Ideas or attributes are drawn from one situation and used to stimulate another idea or concept. Interaction techniques make use of charts which plot one set of factors vertically, the other set horizontally. Associations are then generated by considering all the possible interactions between the horizontal and vertical factors on the chart.

#### 6. Attribute Listing

Attribute listing, developed by Crawford,<sup>15</sup> emphasizes the detailed observation of each particular characteristic or quality of an item or situation. Attempts are then made to change the characteristic or to relate it to a different item.

Creativity generally proceeds through adaptation of what we call the selection of an attribute from one thing and applying it to something else.

...

Did the first man renting automobiles (or something else) see houses (or something else) and so combine houses and automobiles? He might have observed houses being rented. He didn't combine them with automobiles. Instead he pulled out an attribute or idea from the house--renting it--and applied it to automobiles. 16

An attribute can be anything associated with a process or idea—its use, construction, its material, method of sale, etc. Some are

obvious, others are obscure.

This technique may be used in two ways: one may see a process or idea and build upon its attributes, or one may seek something that has an attribute which would solve a particular problem. You build on existing work by adding an attribute, substituting for an existing attribute, or by eliminating an attribute.

Crawford lists the attributes of various objects, or the specifications or the limitations of certain need areas. Then by changing or modifying one or more of the attributes or specifications he brings originally unrelated objects together to form a new combination that better satisfies the need.

The attribute listing method involves looking at the main aspects of a situation. The technique is a much simplified form of what Zwicky calls morphological analysis. Arnold has observed that in using this technique, the more familiar the members of the group are with a certain object or situation, the more difficult it is for them to agree about the basic attributes of that object or situation!<sup>17</sup> He points out that familiarity may place things in the classification of the "obvious", and from then on we tend to neglect reanalysis and reevaluation.

Familiarity can also limit our flexibility and originality in attempting to handle new problems. It tends to establish a very limited number of fixed approaches, and may prevent us from stepping back from our work to view it from new vantage points.

It is only the amateur or tyro who invents anything; the expert has too many reasons why something can't be done, so he never tries.<sup>18</sup>

Another limitation of attribute listing could be its tendency to get the designer too closely restricted to the original concept. This could result in only minor modifications in this concept and not radical changes.

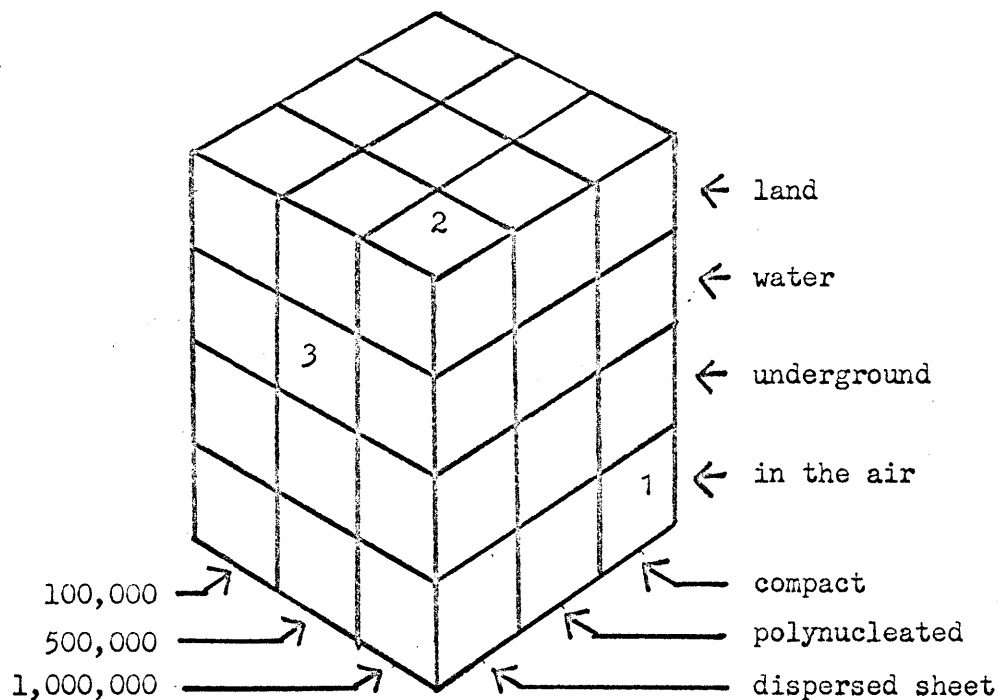
Attribute listing is most effectively applied to very specific problem or needs where specifications are listed with a very definite object or situation in mind. Because of the listing of properties or qualities this technique becomes very similar to the check lists.

#### 7. Morphological Analysis

This technique, developed by Zwicky, is a mechanical means of forcing the association of required functions for an object or environment in order to stimulate unusual design concepts.<sup>19</sup> The major functions of an object or environment's design and the means of performing these functions must be conceived by the individual or group effort. Similar to attribute listing, it is concerned with separating out the independent variables of a problem. Instead of taking the actual physical characteristics, the designer abstracts the relevant design parameters from the object or environment. Once this is done, matrix analysis provides a multitude of object and environment design concepts for evaluation. This technique replaces check lists and attribute listing when the problem becomes less specific and when the designer wants to be as basic, all inclusive and generic as possible.

The procedure is as follows:

The statement of the problem should be as broad and general as possible, and then all of the independent variables must be defined as broadly and completely as possible. Each one of these independent variables becomes an axis on the morphological chart, and if there are "n" independent variables, we will have a chart of "n" dimensions. Each of the independent variables can probably be expressed a number of different ways, and these are laid out with unit dimensions on each of the "n" axes. 20



This could be illustrated by following through a simple example. The above morphological chart is for generating city concepts given the following variables:

1. location: (1) land, (2) water (3) underground, (4) in the air
2. spatial form: (1) compact, (2) polynucleated, (3) dispersed sheet
3. population: (1) 100,000 (2) 500,000 (3) 1,000,000

The diagram of this situation can be thought of as a filing cabinet with drawers operating or opening in all three directions. The contents of each of these drawers will be defined by one of the variations of each of the three variables. Note the three drawers singled out on the chart.

Drawer 1 would be a compact community, located in the air, with a population of 1,000,000.

Drawer 2 would be a dispersed sheet community, located on land, with a population of 1,000,000.

Drawer 3 would be a dispersed sheet community, located on water, with a population of 500,000.

The morphological chart with 36 drawers, representing that many alternative ideas for solving the problem, may have many drawers whose solutions have not been seriously considered. This may be because of absurd or impractical ideas, but it also could be because no one had ever thought of that particular combination.

This is a good method for providing a large variety of design concepts--possibly more than by free association--starting from a few basic ideas about major object or environment functions. It would be useful at the broad and general level where a design concept was being sought. Design techniques can then be used to develop these general concepts.

### Evaluation of Analytic and Interaction Techniques

These idea techniques seem most useful in combination with Design Process 2 which develops a single solution by fragmentation. The analytical qualities of this process and these techniques enable them to work well together. By fragmenting the problem, the sub-parts can be entered into the morphological chart which may allow us to produce new combinations, and in turn, new solutions. Even though this does not produce a unified solution, it exposes the designer to more of the ingredients of the problem than would normally be identified.

In addition, when the problem is fragmented into its parts, attributes from other situations may be utilized in the development of sub-solutions which are then recombined into a single whole solution. Attribute listing is less mechanical than morphological analysis but both are useful in a situation where there are limited resources available to the designer.

The combination of these techniques and Design Process 2 could be used in a cyclical manner, as suggested by Design Process 3.

### Check Lists or 'Idea Needles'

The purpose of the check lists is to focus the designer's attention on a logical list of diverse categories to which the problem could conceivably relate. These are based on the use of words which serve to spark off association chains. The selection of the check list of words should be closely related to the work at hand.

The danger of these check lists is that the questions may

become too vague. But it should be possible to make out particularly meaningful sets of questions for a particular design situation. Even general check lists may be useful in focusing attention on the difficult and important aspects of the problem.

### 8. Osborn Check List

Alex Osborn has classified major ways in which an existing idea may be converted into a new and original idea. He suggests that by thinking in the categories he proposes, an individual or group may be able to produce new ideas for exploration with greater ease.

Osborn compiled the following check list. 21

Put to other uses? New ways to use it? Other uses if modified?

Adapt? What else is like this? What other idea does this suggest? Does past offer parallel? What could I copy? Whom could I emulate?

Modify? New twist? Change meaning, color, motion, sound, odor, form, shape? Other changes?

Magnify? What to add? More time? Greater frequency? Stronger? Higher? Longer? Thicker? Extra value? Plus ingredient? Duplicate? Multiply? Exaggerate?

Minify? What to subtract? Smaller? Condensed? Miniature? Lower? Shorter? Lighter? Omit? Streamline? Split up? Understate?

Substitute? Who else instead? What else instead? Other ingredient? Other material? Other process? Other power? Other place? Other approach? Other tone of voice?

Re-arrange? Interchange components? Other pattern? Other lay-out? Other sequence? Transpose cause and effect? Change pace? Change schedule?

Reverse? Transpose positive and negative? How about opposites? Turn it backward? Turn it upside down? Reverse roles? Change shoes? Turn tables? Turn other cheek?



Combine? How about a blend, an alloy, an assortment, an ensemble? Combine units? Combine purposes? Combine appeals? Combine ideas?

## 9. Polya Check List

Polya suggests another very easy and effective way for developing a questioning habit. He developed the following check list for guidance in solving single-answer mathematical problems, but with a few modifications it could be applied equally well to multi-answer creative problems. The check list not only "exercises questioning, but also fluency, flexibility, and originality through increased observation and association." 22

### Understanding the Problem

**First** What is the unknown? What are the data? What is the condition?

Is it possible to satisfy the condition? Is the condition sufficient to determine the unknown? Or is it insufficient? Or redundant? Or contradictory?

Draw a figure. Introduce suitable notation.

Separate the various parts of the condition. Can you write them down?

### Devising a Plan

**Second** Have you seen it before? Or have you seen the same problem in a slightly different form?

Do you know a related problem? Do you know a theorem that could be useful?

Look at the unknown, and try to think of a familiar problem having the same or a similar unknown.

Here is a problem related to yours and solved before. Could you use it? Could you use its results? Could you use its methods? Should you introduce some auxiliary element in order to make its use possible?

Could you restate the problem? Could you restate it still differently? Go back to definitions.

...

Did you use all the data? Did you use the whole condition? Have you taken into account all essential notions involved in the problem?

### Carrying out the Plan

Third Carrying out your plan of the solution, check each step. Can you see clearly that the step is correct? Can you prove that it is correct?

### Looking Back

Fourth Can you check the result? Can you check the argument? Can you derive the result differently? Can you see it at a glance? Can you use the result, or the method, for some other problem?

While specific check lists are useful for routine procedures, the Polya Check List is a good example of a generalized list which allows the designer to get a fresh look at the problem from several vantage points. Besides having a reminder so that he will not overlook important factors, this list may also spark off new ideas. This check list parallels the design process so could be used at various stages.

I have modified the first stage of Polya's Check List to make it more meaningful to the designer. The other stages seem to be useful as they are.

### Understanding the Problem (Identify the Problem)

First What is the perceived defect or lack in the environment? What is the role? context? constraints? powers? objectives? scope?

Does a solution type(s) suggest itself?

Can a diagram be used to clarify the situation?

Can you isolate the various parts of the design problem?

#### 10. Roget's Thesarus<sup>23</sup>

Associations stimulated by mechanical means allow us to range far and wide until something clicks. The lists are "needles", and each question is twisted around until it applies in some way to the problem.

"Roget juxtaposes positive and negative ideas, grouped in pairs, and the most useful stimulus words will be found under the general headings of Abstract Relations, Space and Matter."<sup>24</sup> An example would be Abstract Relations subdivided into Relation, Order, Number, Time, Change, Causation. These can form a list to stimulate ideas about a certain design concept.

	Concentrated City Form
Abstract Relations	
Relation	
Order	
Number	
Time	
Change	
Causation	

This cross-examination may lead one to seek reasons for the 'relation' of this form to other city forms, the order of the layout, how time has effected this form, changes which are occuring, etc.

#### Evaluation of Check Lists

This group of idea-stimulating techniques is the most universal of the three types. They can be used by a single designer or be a group while developing a design, whether in modifying a past design

or in trying to generate a new one.

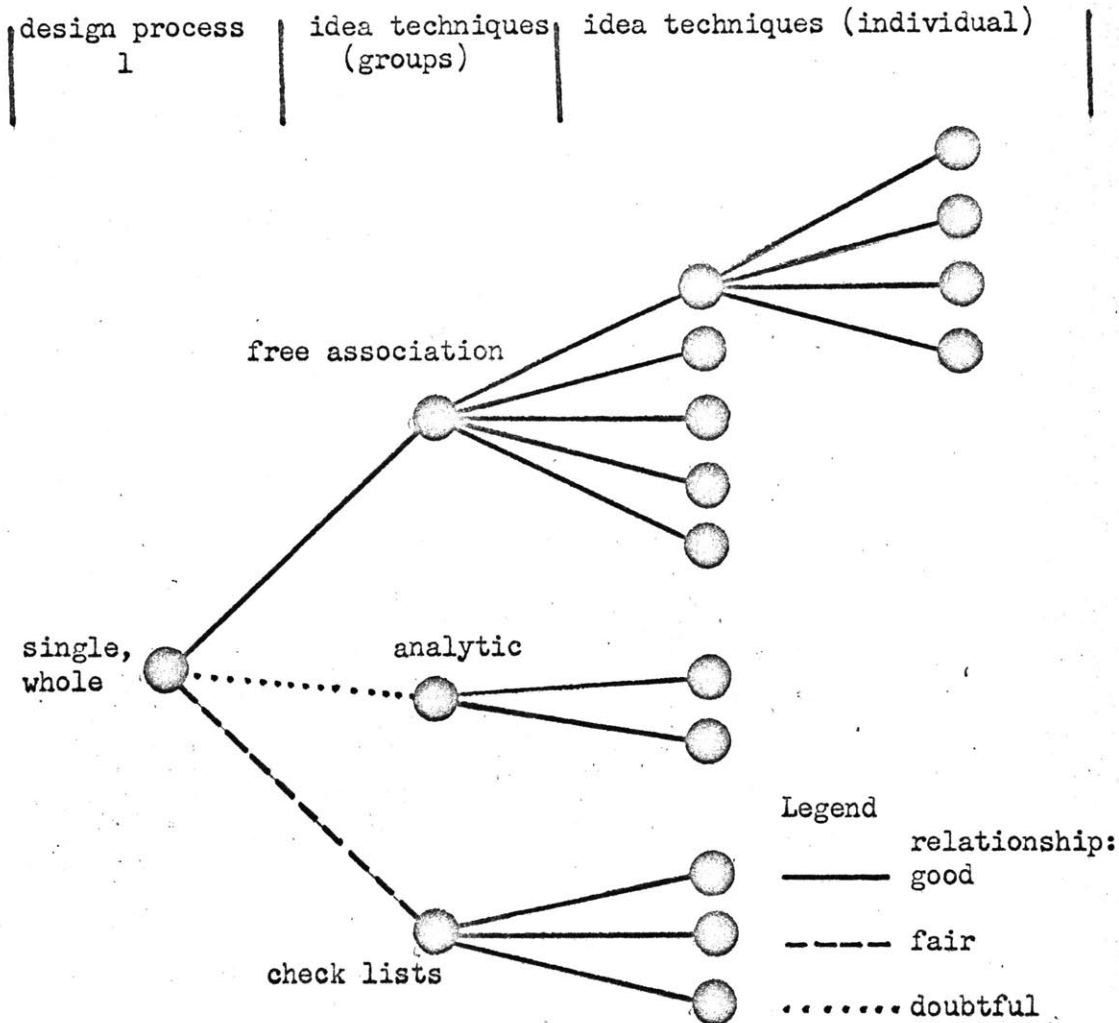
They can be used within any of the design processes and any of the design techniques. In addition, they can be used with the previous idea-generating techniques. For example, the leader of a brainstorming session may use this technique to keep the free flow of ideas coming.

For a specific type of problem it would be most useful to develop a more specialized check list which is more relevant to the problem at hand.

#### Summary of Chapter IV

In this chapter we have discovered relationships between the seven design processes and the three groups of idea-generating techniques. In establishing these relationships it was only necessary to discuss the first three design processes because they are fundamental to the other five design processes.

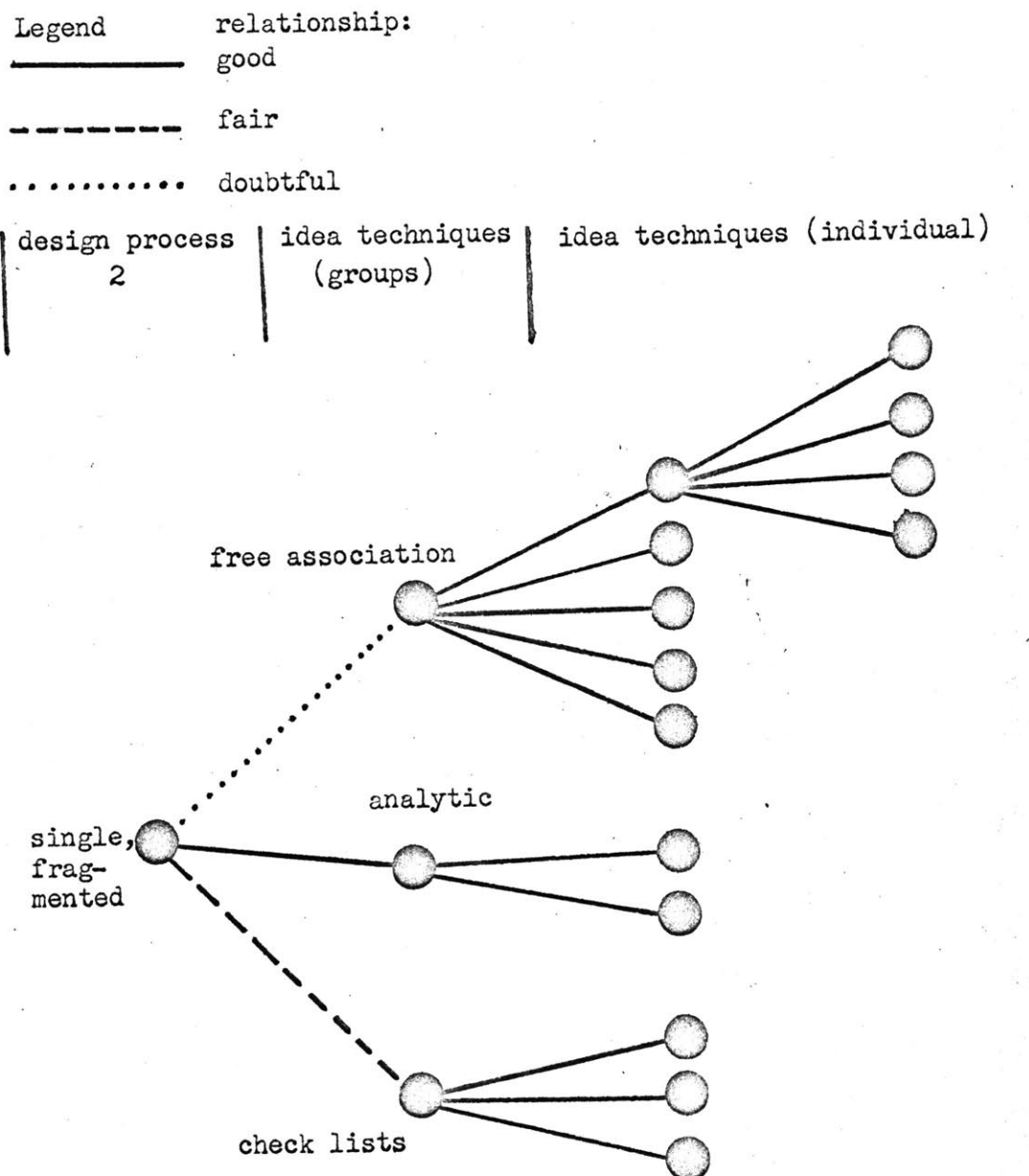
The first design process seems most related to the free-association techniques, and to a lesser degree, the check lists, in that they are mostly concerned with the overall development of a single idea or concept. The relationship between the first design process and the groups of idea-generating techniques can be diagrammed as follows:



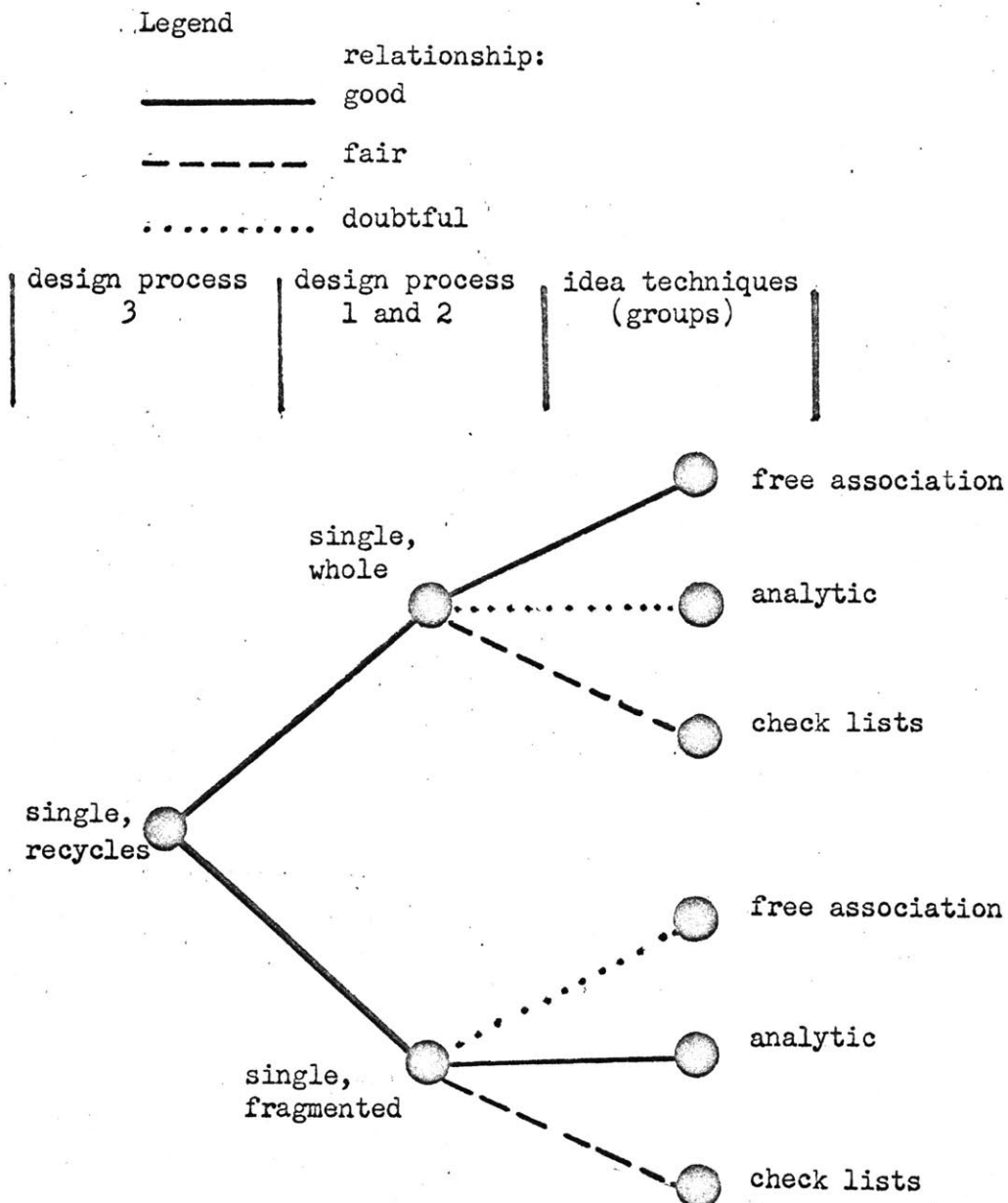
Interaction techniques are more concerned with the interrelationships of all or some of the parts of the problem situation. It therefore seems that the interaction techniques would be very useful in partnership with the second design process which fragments the problem into subproblems. This would facilitate the use of, for example, morphological analysis which also attempts to identify the major functions of a design or to identify the major subproblems in a design situation. Check lists could be used in the development of subproblems.

Free-association techniques could also be used within the second design process for identifying subproblems. Brainstorming could be used to identify the many problems at the offset.

The relationship between the second design process and the idea-generating techniques can be diagrammed as follows:



We have already discussed how either Design Processes 1 or 2 can be used in a cyclical manner within Design Process 3. The groups of idea-generating techniques for Design Processes 1 and 2 would be used within and related to Design Process 3 in the following way:



## CHAPTER V

### DESIGN ENVIRONMENTS

In this chapter we will discuss the Eclectic technique, within which any combination of design processes or design and idea techniques can be used in the development of a solution. In addition, we will discuss two design aids, Discourse and Urban 5, which also allow us to use any of the techniques which we have discussed for the development of a solution. These design aids will be referred to as "design environments".

#### Eclectic Technique

Lynch suggests that perhaps the "safest" of the current design techniques is one which utilizes a combination of many of the techniques mentioned so far: <sup>1</sup> (generating alternatives for single goals, partial solutions for small areas or for single functions of the whole, solutions suggested by existing situations, known stereotypes, random formal plan incrementally developed, etc.) These produce disconnected and partial alternatives which are formulated into a few comprehensive alternatives. They are then evaluated and modified, added to and reevaluated and refined, again checked and rechecked to determine how well they meet the objectives. This is a time-consuming process but it searches for alternatives in a thorough way, with a great deal of evaluation, rejection and refitting during the formulation of alternative proposals, and presents the alter-



natives in a form which allows them to be evaluated.

The designer limits the scope of the search and also the final solution by many personal and subjective assumptions. This limitation is why this technique is operational. The designer can handle complex problems by simplifying or sidestepping some of the complexities and subtleties of the problem. The designer, by using the cyclical "tentative method of design search ... deals directly with the fluidity and ambiguity of objectives and conditions, and prepares the ground for explicit judgement." <sup>2</sup>

Although this is currently the "most rational method" of design which is operational, it still would be comparable to a hand-made, custom-fitted element designed through a process of trial and error in an age where we are capable of solving complex problems at a more comprehensive and refined level.

Urban 5

Urban 5 was

designed to study the desirability and feasibility of conversing with a machine about an environmental design project. The discussion is conducted in both graphics and English, using the computer as an objective mirror of the user's design criteria and form decisions; reflecting responses are formed from a larger information base than the user's personal experience.<sup>3</sup>

The basic idea of Urban 5 is that at many different levels the computer can be a partner in the design process by providing a service that monitors the procedure rather than optimizes or generates solutions. This tool assists the designer in considering a multitude of salient, basic relationships.

In this design aid the user specifies the criteria in English through a typewriter console keyboard and generates physical form (graphically) on a display console with a light pen. The system responds with a state of compatibility or conflict. The designer responds by making a decision. One area of conflict would be where the designer's specified design criteria contradicted the characteristics or implications of the physical form.

The design process is abstracted so that the design procedure can be studied under a range of synthetic conditions. It attempts to abstractly simulate the total design process. The graphical language employed abstracts drawings into a cube--the ten-foot cube is the system's format.

The initial idea for Urban 5 was that enough routines could be written so that the designer could use it for any problem. There would be a vast array of subroutines at his disposal. This now seems

questionable as there are limits--to the storage capacity, and to the time and energy needed for writing the programs. There is no motivation to continue this project in such a direction. Instead, the search will be directed to more general lines of investigation, further pursuing the designer-machine communications potential. In this new approach the designer should have more flexibility in his use of the machine. Instead of having many specific programs we would have a set of general programs which the designer combines in his own way, creating his own package of alternative routines.

Urban 5 has been an interesting investigation into the possibilities of a designer-computer partnership in urban design. Its conclusions seem to be that the designer must have a voice in the selection of the routines he is to utilize in his design problem; and that what are needed are more general programs which can be combined to attack specific problems.

#### Discourse - Computer-Aided Design 4

Discourse is a system of computer programs to assist the designer in developing his design ideas. Discourse is aimed at accommodating the designer's activities in complex problems of large-scale environmental design.

This design aid seeks to improve the designer's performance, not only through using the computer's speed and tirelessness, but also through participating in a man-machine system because this participation will demand clarity of thinking from the designer. The designer quickly sees the consequences of his decisions. This will be facilitated by programs which cover repetitive procedures such as measurement, computations, extended search procedures and the

display of complex information is list form.

Discourse allows the designer to use procedures he was unaware of or had regarded as unfeasible. Each designer selects from a large vocabulary of building blocks his own design-aids. These can easily be modified and replaced, and the designer only uses that part of the system he chooses and modifies it to his needs.

A description of the designer's activities in complex problems of large-scale design according to the authors of Discourse is:

He describes and represents the environment to be designed. He explores the environment to be designed. He explores the environment by investigating relationships within. He identifies and orders the constraints governing the design. He tries design configurations that variously approximate the constraints and conditions of the problem. He tests his designs for internal and external consistency, and for their effects - social, psychological, and economic. And, after he has compared many possibilities, he selects some one or some part of the many to be developed in greater detail. Furthermore, as he works, the designer changes his mind about what is relevant, how he wants to manipulate the environment, what sorts of relationships are important, and what sorts of tests are significant.

Discourse has been prepared to allow the designer to work in this fashion by means of the following design activities:

1. Describing the Environment

The designer places a two-dimensional grid over his environment to identify each location. Attributes are what is or what can be at each location (land, office buildings). An attribute can: (1) vary with different locations, or (2) be constant in different locations. A data file is made with the information.

2. Searching for Groupings and Patterns

Two types of lists are constructed: location lists which include all attributes present at any location; and attribute lists which include everything present at all locations having that attribute.

Other lists are formed: temporary lists which can be terminated by a decision, and permanent lists that remain.

3. Erasing and Correcting

After the designer has explored certain avenues, he may erase his accumulated lists. If he wants to correct the description of the environment he must call the data file.

4. Exhibiting Information

The designer can see what he has done, exhibited in list form.

5. Executing Design Decisions

The act of design is to specify a change to the state of the environment.

Discourse is very similar to Urban 5 but is more general and more flexible. The essence of Discourse is still that of a bookkeeping system which allows the designer to find out how he is doing in the development of a solution at different stages. In addition, the system calls operations for the designer to do.

A major problem in using Discourse is in the beginning stages of the design process. The designer has to specify a great deal of information and data which may be useless later. This can be a loss of both time and money. To correct this the designer could use the "probe" to define the problem more precisely. He could maintain the flexibility that was stated as important by the authors, and not be tied by the investment of establishing a data base.

Usually in design situations so much effort goes into the development of one alternative that it becomes difficult to radically change directions or maintain a wide range of flexibility. This system attempts to correct this.

Frequently a designer is asked to be specific in an area where specific answers are not available. This could be a fundamental problem in the use of these man-machine relationships. Problems are in-

creasing in complexity, machines are becoming more efficient, but man must increase his knowledge and understanding of human problems before a real 'discourse' can be feasible.

## CHAPTER VI

### CONCLUDING REMARKS

In this conclusion I will attempt to relate the design processes and the groups of design and idea techniques. I will also single out those combinations which appear to be most useful to the urban designer in attacking complex continuous design problems.

We have shown how the first two design processes can be used with the third to form the bases of all the rest of the design processes. The last four design processes use the first three processes and their related design and idea techniques in the development in parallel of alternative solutions. This can be done as a single attempt or as part of a recurrent and cyclic design process.

Design and idea techniques have been discussed and related to the three basic design processes. The relationships can be summarized as follows.

#### Design Process I      The Development of a Single Whole Solution

We have related the following groups of design techniques:

- Group A--Adapt Previous Solution
- Group B--Trial and Error
- Group C--Incremental Formal Play
- Group D--Seizing the Essential

In addition, we have the following groups of idea techniques:

- Group A--Free-Association Techniques
- Group C--Check Lists (to a lesser degree)

This combination of Design Process I and the design and idea

techniques listed seems to have the strongest interrelations and mutually supporting roles in the development of a single whole solution.

This particular combination seems to be the strategy most used within the design profession to date. This may help explain our inability to produce new ideas or innovation in solving our more complex problems. On the other hand, this combination presents a safe approach where we are concerned with slow evolution and there are grave consequences of failure. This combination is less precise than may be demanded, and yet it reflects our lack of precise knowledge and understanding in many areas. It has also been used for lack of more adequate design approaches for handling complex problems.

Design Process II      The Development of a Single Solution by Fragmenting the Problem into Subproblems

We have related the following groups of design techniques:

Group E--Fragmenting the Problem

In addition, we have the following groups of idea techniques:

Group B--Analytical and Interaction Techniques

Group C--Check Lists (to a lesser degree)

This combination of Design Process 2 and the design and idea techniques listed seem to form the strongest team in attacking a complex problem by fragmenting the problem and looking for clues in its inherent structure. They are, because of their emphasis on the parts of a problem, mutually supportive in the development of a single solution.

This particular combination appears to be more rigorous and



possibly more useful in complex urban design problems than the last combination. It seeks to attack a problem in a more systematic way which may reveal more comprehensive and innovative solutions to problems. In breaking the problems apart into subproblems, the designer may be able to identify crucial relationships which may not have been discovered had he looked at the problem as an entirety. It is this potential--that of being able to identify crucial internal interrelationships--which may result in the more responsive solutions to problems.

### Design Process III

Design Process I and II and their related design and idea techniques may be used within Design Process III in a recurrent manner. The recurrent nature adds the monitoring of a client group, and the particular techniques that link up with this process allow the designer to explore the consequences of his design proposals generated by Design Process 1 and 2.

#### Group F--Growth Models and Gaming

allows us to explore the consequences and implications of our design decisions.

The design environments--Eclectic techniques, Discourse or Urban 5--are essential in that they allow the designer to use any combination of design processes and related design and idea techniques in the development of solutions to a complex problem. These design environments are trying to provide a system within which the designer

can use his own design strategy while handling problems involving large amounts of varied data which are constantly changing. It has the potential capacity of manipulating and recalling data in order to generate and evaluate a variety of design alternatives, together with the freedom of the designer to use his own strategy by selecting from a vocabulary of building blocks. The coupling of man and machine in Discourse and Urban 5 makes a very important contribution to increasing the capacity of the designer to handle complex urban design problems.

This new direction in urban design suggests that the essential work to be done in developing techniques for preparing and evaluating a set of alternatives is not just in trying to improve any one design process, design technique or idea technique. What also is needed is the development of operational design environments such as Discourse. Some of the improvements needed on such a design environment are: the incorporation of a graphic output; the ability to describe and manipulate data not related to locations; and the development of better bookkeeping, monitoring and evaluation functions.

Before more systematic design environments are perfected, we must at least attempt to use the best available methods in the design of complex problem situations. The eclectic technique of generating alternatives is already developed. It can be expanded or contracted, responding to available resources. Within it can be used growth models and evaluation techniques which consider marginal differences between alternatives. We have in the eclectic method a workable design strategy which permits the designer to work fluidly with ambiguous objectives and conditions in the complex urban environment.

APPENDIX A

A general process for complex, continuous design.

1. First view of the problem is set: role, client, context, constraints, powers, objectives, scope and type of solution.
2. Simultaneously:
  - a. Define first-round, operational criteria.
  - b. Reconnoiter the problem: context, difficulties, possibilities, trends.
  - c. Sketch some first-round alternatives.

Look for fits between these, and restructure the problem.

3. Simultaneously:
  - a. Review and develop criteria and structure of problem with client.
  - b. Identify required data - plan and conduct its collection in compatible language and organize to accept new information.
  - c. Construct a compatible general or partial predictive and evaluative model(s). Run for probable future(s) without intervention.
  - d. Choose a design strategy. Develop a limited set of alternatives, compatible with information and model, conducting partial predictions and evaluations, recycling as information develops.
4. Run model(s) for the set of alternatives (to extent not done in the process of generating them).

Evaluate alternatives by marginal values of criteria achieved, stating costs and probabilities, and to whom costs and benefits accrue.

5. Client chooses one or rejects all. Former leads to internal or external action.
6. If latter, restructure problem: revise model, data, criteria alternatives, role, and re-evaluate until there is a satisfactory fit, or a decision to abandon.
7. Shift to new problem, or to different level of previous problem, retaining previous information. Monitor results.
8. Periodically, re-structure and re-run old problems in light of new information, criteria, results, context, etc.

Massachusetts Institute of Technology  
 Department of City and Regional Planning  
 11.32 City Design                      Fall, 1967

APPENDIX B

A topic outline of some city concepts:

- I. Some general attitudes toward the preferred role and nature of development (often vague and not always mutually exclusive):
  1. Urbanity, diversity, surprise, the picturesque, high levels of interaction.
  2. Symbolic city, ordered and composed, neo-functionalism, city as intricate technical device.
  3. Environment as individually experienced or imaged, "openness," manipulability, sequence, legibility, meaning.
  4. Conservation, ecological relatedness, the city as a balanced stable organism.
  5. City as managed ongoing system, monitoring, the market, the capital web.
  6. Local control, advocacy, pluralism, emphasis on the small social group and local behavior.
- II. Some form models at city or regional scale:
  1. General compositional ideas: star linear and network patterns, dynapolis, megaform, group form, mobile and temporary cities, enclosed cities, "endless" form.
  2. Ideas as to the grouping of function: center hierarchies, satellite towns, neighborhoods, multi-focal and afocal cities.
  3. Texture of space and activity: anti-sprawl and concentration vs. scatteration and low density, green belts wedges and networks, activity and density mix or separation.
  4. Circulation patterns: radio-concentric, two and three-dimensional grids, baroque axes, linear.
  5. Circulation modes: new mass transit devices, small-scale transit and dynamic scheduling, hybrid mass/individual systems, radial feeder systems, segregation of modes, dispersed individual carriers.

### III. Elements and patterns at the project scale:

1. Developmental texture: high units/low cover; medium density/high cover; small units/low density; medium density ground access; small unit/high cover; three-dimensional complex of direct access units; cluster planning.
2. Circulation systems: indirect local streets (curving streets, T joints, cul-de-sacs), pedestrian separation (superblocks, platforms, malls), multipurpose use of rights of way.
3. Open space development: plazas and malls, recreational types and standards, neighborhood commons, junk and action playgrounds, stream valley parks, common lands in subdivisions, greenways, boulevards, parkways and other sequential parks.
4. Design of centers: regional shopping centers, civic centers, intensive urban cores, neighborhood centers, linear centers.
5. Structural models: mobile housing, self-help housing, the various housing types, general purpose structures, space grids, "soft" architecture.

This incomplete list of concepts may be further classified by:

1. The particular objectives for which they are thought to be most useful: increasing or controlling accessibility; reducing danger, stress or nuisance; conservation or contact with nature; flexibility or manipulability; increasing encounter, interaction or sense of community; increasing diversity, choice or opportunity; individual development; efficiency; increasing or equalizing services and facilities; etc.
2. The kinds of situations in which they are thought to be applicable: high or low resources; stable or fluid situations; large and complex or small and simple communities; centralized or dispersed decision making; new building in an undeveloped area, or rebuilding in a previously developed environment; etc.

APPENDIX C

Some performance characteristics of city form.

1. Adequacy: degree to which the capacity and quality of the spaces, channels and terminals match the quantity and nature of the system of persons and their activity, including measures of equity.
2. Accessibility: the cost (time, money, effort) of moving or communicating between activity locations, and the degree of choice of mode; the degree to which communication is controllable by the individual.
3. Diversity: the range of variation of spaces, facilities, qualities, and activities, and the spatial mix or the accessibility of this variation.
4. Stress: the level of physiological or psychological stress put on the individual, due to climate, effort, stimulus, etc; the degree of risk of accident, attack, loss, disease, or death.
5. Legibility: the degree to which the sensuous form is differentiated and structured in time and in space; and its degree of fit to the underlying activity and physical system (congruence).
6. Adaptability: the cost of adapting the physical system to new functions; the degree to which it can easily and directly be modified by the individual or small group (manipulability); the ability of the city system to absorb sudden stress, avoid breakdown, or recover rapidly (resilience); the degree to which new environmental patterns are generated and evaluated.
7. Efficiency: the cost of constructing and maintaining the environment, at given levels of achievement of the criteria.

Massachusetts Institute of Technology  
Department of City and Regional Planning  
11.32 City Design     Kevin Lynch, 1967

APPENDIX DCheck List

This check list can be varied or extended to suit different design situations. The list given here is a basic list for the field of consumer durables. ...

- 0 programming
  - 0.1 receive training
  - 0.2 accumulate experience
  - 0.3 receive brief
    - 0.3.1 identify authority to whom answerable
    - 0.3.2 identify type of task
    - 0.3.3 identify nature of end-product
    - 0.3.4 define form of submission required
    - 0.3.5 define facilities and/or fee envisaged
    - 0.3.6 define time limitations
- 1 data
  - 1.1 goals
    - 1.1.1 define corporate policy
    - 1.1.2 define trading policy
    - 1.1.3 define project aims
    - 1.1.4 define problem aims
    - 1.1.5 identify reasons for examining this problem now
  - 1.2 constraints
    - 1.2.1 identify national constraints
    - 1.2.2 identify trade constraints
    - 1.2.3 identify mandatory company constraints
    - 1.2.4 identify contractual constraints
    - 1.2.5 identify budgetary constraints
    - 1.2.6 identify marketing constraints
    - 1.2.7 identify manufacturing constraints
- 2 analysis
  - 2.1 crucial issues
    - 2.1.1 analyse goals and define criteria for measuring success
    - 2.1.2 analyse constraints and define field of manoeuvre available
    - 2.1.3 identify crucial issues
  - 2.2 course of action
    - 2.2.1 review experience of similar and analogous problems
    - 2.2.2 collect case histories of similar problems handled elsewhere
    - 2.2.3 list courses of action available
    - 2.2.4 select a promising course of action
    - 2.2.5 test suggested course of action (a pilot study?)
    - 2.2.6 reappraise and if necessary suggest further course of action
    - 2.2.7 reappraise timetable
    - 2.2.8 reappraise facilities

- 2.3 information
  - 2.3.1 collect available information on environment at point of use
  - 2.3.2 collect available information on identity of user
  - 2.3.3 collect available information on user ergonomics
  - 2.3.4 collect available information on user motivation
  - 2.3.5 collect available information on product function
  - 2.3.6 collect available information on product mechanics
  - 2.3.7 collect available information on product finish
  - 2.3.8 collect available information on product aesthetics
  - 2.3.9 collect available information on market environment
  - 2.3.10 collect available information on competitive products
  - 2.3.11 collect available information on product archetype
  - 2.3.12 collect available information on brand predecessors
  - 2.3.13 collect available information on maker's house style
  - 2.3.14 collect available information on ruling market prices
  - 2.3.15 collect available information on economic quantities
  - 2.3.16 collect available information on production facilities
  - 2.3.17 collect available information on limiting dimensions
  - 2.3.18 collect information on available materials
- 2.4 subproblems
  - 2.4.1 list matters requiring evaluation or decision
  - 2.4.2 pair interdependent matters so as to form all matters into subproblems
  - 2.4.3 identify the sequence of dependence of subproblems upon one another (arrow diagram)
  - 2.4.4 distinguish problems about means from problems about ends
- 2.5 subproblem analysis (repeated for each subproblem in sequence)
  - 2.5.1 list the factors in the subproblem
  - 2.5.2 identify the goal to be achieved or the condition to be satisfied
  - 2.5.3 establish the connection between the factors and the goal or condition
  - 2.5.4 estimate the degree of significance of the subproblem and the quality of evaluation required in the solution of it
  - 2.5.5 identify those factors where the data values are externally imposed
  - 2.5.6 identify those factors where the data values may be voluntary fixed by the designer
  - 2.5.7 identify those factors where the data are dependent variables
  - 2.5.8 collect necessary data
  - 2.5.9 evaluate data so that satisfaction of goal or condition is optimum
  - 2.5.10 delineate maximum feasible range of variation of solutions
- 2.6 rank ordering of subproblems
  - 2.6.1 taking every permutation of pairs of subproblems, identify which in each pair must take precedence if their optimum solutions should prove incompatible



- 2.6.2 rank order the complete list of subproblems in order of precedence
- 2.6.3 identify those pairs where optimum solutions are in fact mutually compatible
- 2.6.4 similarly, identify those pairs where the optimum solution of one is compatible with feasible (but not the optimum) solutions of the other
- 2.6.5 similarly, identify those pairs where feasible solutions (but not the optimum solutions) are mutually compatible
- 2.6.7 select all the subproblems listed under 2.6.6, together with all those subproblems listed under 2.6.4 and 2.6.5 which also stand high on the rank ordered list, and then re-examine them
  
- 2.7 reappraisal
  - 2.7.1 in the light of 2.4 and 2.5, restate the problem set out in 1.1
  - 2.7.2 in the light of 2.6 reappraise the crucial issues set out in 2.1
  - 2.7.3 reappraise and if necessary reformulate a course of action, previously set out in 2.2
  - 2.7.4 reappraise timetable
  - 2.7.5 reappraise facilities
  
- 3 synthesis
  - 3.1 propose outline solutions
    - 3.1.1 propose outline ideal overall solution (the perfect solution) according to goals and criteria for measuring success (see 2.1.1, 2.7.1)
    - 3.1.2 propose outline obvious solution according to constraints and field of manoeuvre available (see 2.1.2 and 2.7.1)
    - 3.1.3 propose outline critical solution(s) in the light of crucial issues (see 2.1.3 and 2.7.2)
    - 3.1.4 catalogue the properties of existing designs, distil from these the current archetype and propose a new conventional solution
    - 3.1.5 log precedents, catalogue properties of antecedent designs, extrapolate properties and postulate trend solution(s)
    - 3.1.6 review analogous problems handled elsewhere and identify relevant overall or partial solutions
  - 3.2 test promising overall solutions
    - 3.2.1 from the outline overall solutions listed in section 3.1 select the most promising solutions
    - 3.2.2 for each selected proposed solution take each subproblem in rank-ordered list of subproblems (see 2.6.2 and 2.6.7) and develop design details to the point of distinguishing feasibility or non-feasibility
    - 3.2.3 list resulting feasibility partly developed designs and re-appraise in the light of goals, constraints and facilities (see 2.7)

- 3.2.4 select the most promising designs for further development
- 3.3 (if necessary) test obstructed overall solutions, ie, those which still have an unresolved element
  - 3.3.1 from the outline overall solutions listed under 3.1, select partial solutions or partially obstructed possible solutions
  - 3.3.2 for each selected possible solution divide into overlapping partial solutions
  - 3.3.3 seek in widening circles of analogous problems means for reconciling incompatible overlaps and/or for bridging gaps
  - 3.3.4 check partial solutions and permute for better combinations
  - 3.3.5 for each reconstructed possible overall solution take each subproblem and develop design outlines to the point of distinguishing feasibility or non-feasibility
  - 3.3.6 list resulting feasible partly developed designs and reappraise in the light of goals, constraints and facilities (see 2.7)
  - 3.3.7 select the most promising designs for development

Archer, L. Bruce. "Systematic Methods for Designers,"  
Design, No. 172, 174, 176, 179, 181 (1963-1964).

## FOOTNOTES

### CHAPTER I

<sup>1</sup>Edmund Bacon, "Urban Design as a Force in Comprehensive Planning," A.I.P. Journal, (Feb. 1963). Also, Class Notes: 11.32 City Design, Department of City and Regional Planning, (Massachusetts Institute of Technology, Fall, 1967).

<sup>2</sup>P.H. Roe, G.N. Soulis, and V.K. Handa, The Discipline of Design, (Boston: Allyn and Bacon, 1967), pp. 128-175.

### CHAPTER II

<sup>1</sup>Bruce Archer, "Examining the Evidence--Part Four", Design, 179, (1964), p. 70. Also, Class Notes: 11.32 City Design, Department of City and Regional Planning, (Massachusetts Institute of Technology, Fall, 1967). Also, Christopher Alexander, Notes on the Synthesis of Form, (Cambridge: Harvard University Press, 1967)

<sup>2</sup>Bacon

<sup>3</sup>For example, the SCSD program in California, inspired by Ezra Ehrenkrantz, which has resulted in the building of over twelve high school campuses.

<sup>4</sup>William Michelson, "Urban Sociology as an Aid to Urban Physical Development: Some Research Strategies," Journal of the A.I.P. (March, 1968), p. 106.

<sup>5</sup>For a discussion of Adaptability see Kevin Lynch, "Environmental Adaptability," Journal of the A.I.P., Vol. XXIV, No. 1, (1958) or G. Aylward, "Environmental Adaptability," (Unpublished Master's thesis, Department of City and Regional Planning, Massachusetts Institute of Technology, 1966)

<sup>6</sup>For an attempt to develop a systematic technique for evaluating complex urban designs see, Duncan G. Hudson, Jr., "Evaluate. The Quantification of Evaluation: A Semi-Mechanical Method of Evaluating and Modifying the Design of Urban Areas," (Unpublished Ph.D. dissertation proposal, Department of City and Regional Planning, Massachusetts Institute of Technology, March, 1968)

<sup>7</sup>J.C. Jones, "Design Methods Reviewed", The Design Method, ed. Sydney A. Gregory, (London: Butterworths, 1966), p. 302.

## CHAPTER III

<sup>1</sup>Usher, Abbott, and Payson, A History of Mechanical Inventions, (Boston: Beacon Press, 1959), pp. 60-72.

<sup>2</sup>The idea and the quoted example were developed by David Parsons as an IBM Fellow at the Harvard Graduate School of Design. "Performance Design," Progressive Architecture, (August, 1967), pp. 111, 112.

<sup>3</sup>Serge Boutourline, "The Concept of Environmental Management," (Reprinted from Dot Zero IV, Sept., 1967)

<sup>4</sup>Lynch. Also, Aylward.

<sup>5</sup>Kevin Lynch, "Quality in City Design," Who Designs America?, ed. Laurence B. Holland, (New York: Anchor Books, 1966), p. 145.

<sup>6</sup>John Arnold, "Professional Creativity", Creativity, ed. Paul Smith, (New York: Hastings House Publishers, 1959), p. 28.

<sup>7</sup>Lynch, "Quality in City Design", p. 145.

<sup>8</sup>Ibid.

<sup>9</sup>For a thorough description of this method see: Bruce L. Archer, "Systematic Methods for Designers," Design, No. 172, 174, 176, 179, 181, (163-164).

<sup>10</sup>For a case study of this technique, see: Allen Bernholtz and Edward Bierstone, "Computer-Augmented Design," Design Quarterly, 66/67. Also, see: Christopher Alexander, Notes on the Synthesis of Form, (Cambridge: Harvard University Press, 1967).

<sup>11</sup>Christopher Alexander, and Marvin L. Manheim, "HIDECS 2: A Computer Program for the Hierarchical Decomposition of a Set with an Associated Linear Graph," (Cambridge: The M.I.T. Press, 1962).

<sup>12</sup>Christopher Alexander, "HIDECS 3: Four Computer Programs for the Hierarchical Decomposition of Systems which have an Associated Linear Graph," (Cambridge: The M.I.T. Press, 1963).

<sup>13</sup>Kenneth J. Schlager, "A Land Use Plan Design Model," Journal of the A.I.P., (May, 1965).

<sup>14</sup>U.S., Office of Economic Opportunity, Community Action and Urban Housing, (November, 1967).

<sup>15</sup>Joseph Esherick, "Problems of the Design of a Design System," Conference of Design Methods, eds., J.C. Jones and D.G. Thornley, (1962)

## CHAPTER IV

<sup>1</sup>Roe, Soulis, Handa, 191.

<sup>2</sup>Charles S. Whiting, Creative Thinking, (New York: Reinhold Publishing Co., 1958), pp.35-36.

<sup>3</sup>A.F. Osborn, Applied Imagination, (New York: Charles Scribner's Sons, 1961).

<sup>4</sup>Whiting, 90.

<sup>5</sup>Ibid., 115-118.

<sup>6</sup>John W. Haefele, Creativity and Innovation, (New York: Reinhold Publishing Co., 1962), p. 145.

<sup>7</sup>Whiting, 89-90.

<sup>8</sup>John R.M. Alger, and Carl V. Hays, Creative Synthesis in Design, (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1964), pp. 47-49.

<sup>9</sup>Ibid., 18.

<sup>10</sup>See for case study: William J.J. Gordon, "Operational Approach to Creativity", (Reprinted from Harvard Business Review, November-December, 1956). Also see: William J.J. Gordon, Synectics, (New York: Harper and Brothers, 1961)

<sup>11</sup>John Arnold, "Useful Creative Techniques," A Source Book for Creative Thinking, ed., S.J. Parnes and H.F. Harding, (New York: Charles Scribner's Sons, 1962), pp. 266-267.

<sup>12</sup>This idea technique was used in a City Design Studio, Spring, 1968, at Massachusetts Institute of Technology. It was suggested by Robert Schwartz who hopes to publish it.

<sup>13</sup>Haefele, 151-155.

<sup>14</sup>"Bionics", Engineering Digest, (April and May, 1965).

<sup>15</sup>Robert P. Crawford, Direct Creativity, (Wells, Vermont: Fraser Publishing Co., 1964)

<sup>16</sup>Ibid., 14.

<sup>17</sup>Arnold, "Useful Creative Techniques," 260-264.

<sup>18</sup>Ibid., 255.

<sup>19</sup>Ibid., 255. Developed by Fritz Zwicky.

<sup>20</sup>Ibid., 255-257.

<sup>21</sup> Osborn, 318.

<sup>22</sup> G. Polya, How to Solve It, (Garden City, New York: Anchor Books, 1957), pp. xvi-xvii.

<sup>23</sup> Roget's Thesaurus, ed. Mawson, (New York: Pocket Books, 1966)

<sup>24</sup> Ibid., xiv-xxviii

#### CHAPTER V

<sup>1</sup> Lynch, "Quality in City Design", 149.

<sup>2</sup> For a description of this at another scale, see: Kevin Lynch, Site Planning, (Cambridge, Mass.: The M.I.T. Press, 1962), Chapter 8.

<sup>3</sup> Nicholas Negroponte, and Leon Groisser, Urban 5: An On-Line Urban Design Partner, International Business Machines Corporation, (Cambridge: Cambridge Scientific Center, 1967)

<sup>4</sup> William Porter and Others, Discourse: A User's Manual, (Department of City and Regional Planning, Massachusetts Institute of Technology, April, 1968). See also: William Porter, A Program for Research of Computer-Aided Design, (Department of City and Regional Planning, Massachusetts Institute of Technology, March, 1968)

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